# Learning Outcomes based Curriculum Framework

# (LOCF)

# for

# Undergraduate Programme

# B.Sc. (Geology)

# 2022

## DEPARTMENT OF GEOLOGY

## COTTON UNIVERSITY

## GUWAHATI-781001, ASSAM

# Preamble

Higher education plays a critical role in securing gainful work and/or offering further access to higher education. As a result, improving the quality of higher education should be given top priority in order to enable the next generation of students to acquire the skills, training, and knowledge they need to improve their thinking, comprehension, and application abilities and prepare them to compete, succeed, and excel globally.

The Cotton University envisions all of its programmes in the best interests of its students, and in this effort, it has given all of its Undergraduate courses a new perspective. For all of its Undergraduate programmes, it uses a Learning Outcome-based Curriculum Framework (LOCF).

At the undergraduate level, the LOCF approach is intended to provide a focused, outcome-based curriculum with an agenda to shape teaching-learning experiences in a more student centric manner. The LOCF strategy has been implemented to enhance students' experiences as they participate in their chosen programme. Students will be prepared for both academics and employment through the Undergraduate Programs.

The syllabus developed for B. Sc. (Honours) in Geology has the provision of ensuring the integrated personality of the students in terms of providing opportunity for exposure to the students towards Core Courses, Discipline Specific Courses, Generic Elective Courses, Ability Enhancement Courses and Skill Enhancement Courses with special focus on technical, communication and subject specific skills through practical and other innovative transactional modes to develop their employability skills.

**Nature and extent of UG program in Geology**

The Bachelor of Science in Geology is a three-year undergraduate degree programme focusing on earth science. The course covers the compositions, history, and other processes involving rocks, minerals, and other solid substances, as well as the compositions, history, and other processes involving them.

The curriculum is meant to give students a solid theoretical foundation and practical instruction in all elements of geology, as well as to help them understand the value of geology in various situations. A variety of Generic electives from adjacent disciplines like as Physics, Chemistry, Mathematics, and Computer Science have been incorporated in this framework to ensure the adoption of a holistic educational strategy.

Furthermore, given the importance of B.Sc. Geology graduates' core competency in the subject matter, both academic and practical, significant consideration has been given to their employability.

After completing the B.Sc. (Honours) course, students are entitled to apply for M. Sc./ M. Tech/M. Sc. Tech. courses in Geology, Applied Geology, Remote Sensing, Geo-

informatics, Environmental science, Petroleum geology, and Mining Engineering at various Indian and international universities. For civil service, Forest Service, and comparable examinations, geology is one of the optional courses.

They are eligible for UPSC examinations to join the Geological Survey of India (GSI) and the Central Ground Water Board (CGWB) if they have a postgraduate degree in geology. Geologists are likewise in high demand among paramilitary forces. Geologists with a lot of experience and education can apply for top jobs in the government, industry, and education.

**Aims of the UG programme in Geology**

Create the facilities and environment necessary to introduce and consolidate the knowledge gained at the +2 level, as well as to motivate and inspire students to develop a strong interest in geology, develop a broad and balanced knowledge and understanding of geological concepts, principles and theories of stratigraphy, geological mapping, natural resource exploration, and an understanding of earth evolution.

To show the concepts, principles, and theories studied in the classrooms, students learn, create, and conduct experiments in the labs.

Develop the capacity to apply theoretical and practical geology information gained in the classroom and laboratory to specific challenges.

Bring the student to the enormous spectrum of geosciences as a theoretical and experimental science with applications in tackling most of nature's geogenic problems, such as disaster management, watershed management, water pollution, oil exploration and mining, and so on.

Incorporate the importance of integrating Geosciences as one of the most significant branches of science for pursuing interdisciplinary and multidisciplinary higher education and/or research.

To underline the relevance of geology as the most significant field for sustaining existing industries and establishing new ones in order to provide jobs at all levels.

Through intensive laboratory classes, fieldwork, group debates, and seminar presentations, equip students with critical thinking, problem solving, communication skills, and teamwork.

**Program Specific Outcomes in B. Sc. (Honours) Geology**

The student graduating with the Degree B. Sc. (Honours) Geology should be able to -

**PSO1 C**omprehend the nature and origins of various aspects of the earth system, such as planetary objects, their origins, components, and operational activities in the past and present.

**PSO2** Obtain a theoretical framework for comprehending the nature of geological materials such as rocks, minerals, and fossils.

**PSO3** Acquire a solid base of knowledge in the science of geology as a whole as well as earth materials, earth history, sedimentation and stratigraphy, deformational processes and structural features, geotectonics and geomorphic processes and landforms.

**PSO4** Acquire a fundamental/systematic or coherent understanding of the academic field of geology, its various learning areas and applications in basic geology such as mineralogy, petrology, stratigraphy, palaeontology, economic geology, hydrogeology.

**PSO5** Integrate observations and theory in order to describe natural geological processes in the past and present, as well as to comprehend geological time scales.

**PSO6** Use material and process expertise in mineral and energy exploration, soil and water resource management, environmental aspects of geology and engineering geological aspects.

**PSO7** Understand the significance of RS&GIS, mathematical modelling, simulation, and computation, as well as the function of approximation and mathematical techniques in describing the physical world.

**PSO8** Make good field observations during field excursions and relate their understanding of various structural and petrological features learnt in classroom for correct interpretation.

**PSO9** Communicate confidently and write geological reports.

**PSO10** Demonstrate content knowledge appropriate to professional career goals.

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# Choice Based Credit System (CBCS)

Cotton University) has laid the road map for a Choice-Based Credit System (CBCS) and Continuous Assessment and Grading Pattern (CAGP) in a semester-based system. These are important components of reform in higher education in India, and are practised widely in our academic institutions. In a choice-based system, students are given opportunities to pursue courses of interest across disciplines and faculties, in addition to their core subject of interest. While choices that are offered are usually determined by logistic requirements and availability of resources, these will increase with time as our infrastructure and capacities improve. The number of credits in a course is closely related to the number of teaching-learning hours; and the L-T-P (Lectures-Tutorials-Practicals) structure encourages students towards self-learning or learner-centric approaches. The students have more opportunities to develop and nurture their creative abilities, and be exposed to the methodologies of academic work. The credit system, in principle, also enables the portability of what a student has learnt from one institution to another. Learning is a continuous process. Frequent assessments aid this process and also reduce the emphasis on an end-semester examination, thereby reducing the stress on both students and teachers.

## COURSE STRUCTURE

A. **Outline of Courses and Credits**

The B.Sc. with honours programmes will consist of six semesters with minimum credits required for the complete program being 140.

Each course in a programme will be from one of the following categories:

**1. Core Course:** A course which should compulsorily be studied by a candidate as a core requirement is termed a Core Course.

**2. Elective Course:** A course which can be chosen from a pool of courses and which may extend the discipline / subject of study or which provides exposure to some other discipline/subject or which enhances the student's proficiency or skill is termed an Elective course.

(i) **Discipline Specific Elective (DSE) Course:** An elective course offered under the main discipline / subject of study is a Discipline Specific Elective.

(ii) **Generic Elective (GE) Course:** An elective course chosen from an unrelated discipline/subject is a Generic Elective.

**3. Ability Enhancement (AE) Courses:** The ability enhancement courses are of two types.

(i) **Ability Enhancement Compulsory Course (AECC):** These comprise two courses which are mandatory for all disciplines.

(a) Environmental Studies

(b) English / MIL.

(ii) **Skill Enhancement Course (SEC):** These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge and should contain both theory and lab/hands-on / training / field work. The primary purpose is to provide students with life-skills in hands-on mode to increase their employability.

**4. Practical / Tutorials:** One practical / tutorial is to be provided with every core and discipline specific / generic elective paper.

## COURSE STRUCTURE AND CREDIT DISTRIBUTION FOR B.SC. IN GEOLOGY

| Semester | Core Course (14) Total Credit 14*6= 84 | Ability Enhancement Compulsory Course (AECC) (2) Total Credit 2*2= 4 | Skill Enhancement Course (SEC) (2) Total Credit 2*2= 4 | Discipline Specific Elective (DSE) (4) Total Credit 4*6= 24 | Generic Elective: (GE) (4) Total Credit 4*6= 24 | Credits |
|---|---|---|---|---|---|---|
| I | C1 (6)<br>C2 (6) | Env. Studies.(2) | | | GE-1(6) | 20 |
| II | C3 (6)<br>C4 (6) | Eng / MIL(2) | | | GE-2(6) | 20 |
| III | C5 (6)<br>C6 (6)<br>C7 (6) | | SEC-1(2) | | GE-3(6) | 26 |
| IV | C8 (6)<br>C9 (6)<br>C10 (6) | | SEC-2(2) | | GE-4(6) | 26 |
| V | C11 (6)<br>C12 (6) | | | DSE-1(6)<br>DSE-2(6) | | 24 |
| VI | C13 (6)<br>C14 (6) | | | DSE-3(6)<br>DSE-4(6) | | 24 |
| Credit | 84 | 4 | 4 | 24 | 24 | 140 |

## Evaluation, Grading and Examinations

1. Evaluation of the student will be carried out through a grading system. For each course a letter grade will be awarded which is converted to a grade point according to the following scheme.

2. The evaluation over a semester will be based mainly on two examinations. The first one at the middle of each semester will be the mid-semester examination (briefly MIDSEM) and another at the end of the semester called the end-semester examination (briefly ENDSEM). The MIDSEM will be of 30 marks and the ENDSEM of 70 marks. For courses with a practical component of 1 or 2 credits a practical examination of 30 marks will be held at the end of the semester. For courses with 2 credits or less, the evaluation will be on the basis of a single ENDSEM examination of 50 marks.

Letter Grades and Grade Points

| Letter Grade | Grade Point | |
|---|---|---|
| O | 10 | Outstanding |
| A+ | 9 | Excellent |
| A | 8 | Very Good |
| B+ | 7 | Good |
| B | 6 | Above Average |
| C+ | 5 | Average |
| C | 4 | Pass |
| F | 0 | Fail |
| Abs | 0 | Absent |

3. The MIDSEM examination will be of 90 minutes duration and the ENDSEM will be of 3hours duration, while the 50 marks ENDSEM examination for courses of 2 credits or less will be of 2 hours duration.

4. In order to continuously assess a student's progress, further evaluation through class tests/home assignments/field work/seminars etc. may be employed. These are to be considered part of the MIDSEM. The total marks of any form of evaluation other than the MIDSEM examination cannot exceed 15 marks to ensure that the dominant weightage is given to the MIDSEM examination. The MIDSEM marks will be evaluated using the following Formula:

$$\frac{\text{Total marks obtained in (midsem exam + classtest/assignment/fieldwork/seminar)}}{\text{Full marks of (midsem exam[30] + classtest/assignment/fieldwork/seminar[15])}} \times 30$$

The MIDSEM examination of 30 marks cannot be substituted by any other form of

evaluation for a course with more than 2 credits.

5. As mentioned earlier, the ENDSEM written examination will be of 70 marks for courses with or without a practical component. For courses with a practical component, a 30 mark examination will be held and the marks for the ENDSEM examination will be calculated as follows:

$$- \frac{\text{marks obtained in (theory paper + practical paper)}}{\text{full marks of (theory paper[70] + practical paper[30])}} \times 70$$

6. The total of MIDSEM and ENDSEM will clearly be a score out of a total of 30 + 70 = 100 marks respectively for each course and this mark is the raw score to be converted to a letter grade.

7. To be eligible for a minimum passing grade, a student must obtain a minimum of 9 marks out of 30 in the MIDSEM, a minimum of 21 marks out of 70 in the ENDSEM and a minimum of 12 out of 30 in the practical examination. For a course of 2 credits or less, a student has to obtain a minimum of 15 marks out of 50.

8. It will be mandatory to appear in both the MIDSEM and the ENDSEM examinations as well as the practical examination (for a course with a practical component).

9. The Dissertation/Project Work **DPW** course ( in place of a **DSE** course in the undergraduate programme and compulsory in the postgraduate programme) will be evaluated on the basis of thesis/project report submitted to the department and an oral presentation followed by a viva-voce examination conducted by a panel of at least two members. One of the members will be an external examiner and another member will be the student's supervisor/guide for the **DPW** course.

10. The CGPA of the primary discipline of study, namely **core courses** and **DSE** will be separately shown in the gradesheet. Additionally, the CGPA, taking into account all the courses completed during the programme will also be shown in the final gradesheet.

12. The credit break-up in **L-T-P** format for each paper should be shown in the gradesheet.

13. A departmental committee should be formed in each department to moderate the question papers of the MIDSEM written examination.

# GEOLOGY

## FIRST SEMESTER

**PAPER: GLY 101C** **L+T+P=4+0+2= 6 credits**
**General Geology**
**Geomorphology**
**General Geology and Geomorphology Practical**

**PAPER: GLY 102C** **L+T+P=4+0+2= 6 credits**
**Crystallography**
**Crystal Chemistry**
**Crystallography Practical**

**PAPER: GLY 103G** **L+T+P=4+0+2= 6 credits**
**Essentials of Geology**
**Practicals**

## SECOND SEMESTER

**PAPER: GLY 201C** **L+T+P=4+0+2= 6 credits**
**Mineralogy**
**Mineralogy Practical**

**PAPER: GLY 202C** **L+T+P=4+0+2= 6 credits**
**Geochemistry**
**Optical Mineralogy**
**Optical Mineralogy Practical**

**PAPER: GLY 203G** **L+T+P=4+0+2= 6 credits**
**Rock and Minerals**
**Practicals**

## THIRD SEMESTER

**PAPER: GLY 301C** **L+T+P=4+0+2=6 credits**
**Structural Geology**
**Structural Geology Practical**

**PAPER: GLY 302C** **L+T+P=4+0+2= 6 credits**
**Igneous Petrology**
**Igneous Petrology Practical**

**PAPER: GLY 303C** **L+T+P=4+0+2= 6 credits**
**Sedimentary Petrology**
**Geotectonics**
**Sedimentary Petrology Practical**

**PAPER: GLY 304G** **L+T+P=4+0+2= 6 credits**
**Physics and Chemistry of the Earth**
**Practicals**

## FOURTH SEMESTER

**PAPER: GLY 401C** **L+T+P=4+0+2= 6 credits**
**Metamorphic Petrology**
**Metamorphic Petrology Practical**

**PAPER: GLY 402C** **L+T+P=4+0+2= 6 credits**
**Principles of Stratigraphy**
**Geological Field Work - I**

**PAPER: GLY 403C** **L+T+P=4+0+2= 6 credits**
**Indian Stratigraphy**
**Seminar and Home Assignment**

**PAPER: GLY 404G** **L+T+P=4+0+2= 6 credits**
**Land Surface Processes and Landforms**
**Practicals**

## FIFTH SEMESTER

**PAPER: GLY 501C** **L+T+P=4+0+2= 6 credits**
**Palaeontology**
**Palaeontology Practical**

**PAPER: GLY 502C** **L+T+P=4+0+2= 6 credits**
**Hydrogeology**

**Engineering Geology**
**Hydrogeology and Engineering Geology Practicals**

**PAPER: GLY 503 (DSE-1)** **L+T+P=4+0+2= 6 credits**
**Fuel Geology**
**Fuel Geology Practicals**

**PAPER: GLY 504 (DSE-2)** **L+T+P=5+1+0= 6 credits**
**Prospecting**
**Mining Geology**

## SIXTH SEMESTER

**PAPER: GLY 601C** **L+T+P=4+0+2= 6 credits**
**Economic Geology**
**Economic Geology Practical**

**PAPER: GLY 602C** **L+T+P=4+0+2= 6 credits**
**Remote Sensing and GIS**
**Remote Sensing and GIS Practical**

**PAPER: GLY 603 (DSE-3)** **L+T+P=4+0+2= 6 credits**
**River Science**
**River Science Practical**

**PAPER: GLY 604 (DSE-4)** **L+T+P=4+0+2= 6 credits**
**Environmental Geology**
**Geological Field Work – II**
**Group Discussion**

# DETAILED SYLLABUS

## FIRST SEMESTER

**PAPER: GLY 101C** **L+T+P=4+0+2= 6 credits**
**General Geology**
**Geomorphology**
**General Geology and Geomorphology Practical**

**PAPER: GLY 102C** **L+T+P=4+0+2= 6 credits**
**Crystallography**
**Crystal Chemistry**
**Crystallography Practical**

**PAPER: GLY 103G** **L+T+P=4+0+2= 6 credits**
**Essentials of Geology**
**Practicals**

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**PAPER: GLY 101C (General Geology and Geomorphology)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**

After studying this course the student will be able to:

**CO1** Know about various branches of earth sciences and scope of Geology and its relation to various branches of science.

**CO2** Have the concept of time in geological studies, rock types, solar system.

**CO3** Know about the relation amongst lithosphere, hydrosphere, atmosphere and biosphere, have an idea about the continents and ocean basins and their evolution.

**CO4** Know the different aspects of earthquake and earthquake zones in India.

**CO5** Understanding geomorphic processes and the resulting common landforms.

**(ii) Broad contents of the course**

The paper presents about various branches of earth sciences, scope of Geology and its relation to various branches of science, about rock types, the solar system, about the formation of core, mantle, crust, hydrosphere, atmosphere and biosphere. Have an idea

about the continents and ocean basins and their evolution, Volcanoes and their distribution, different aspects of earthquake and earthquake zones in India.

The paper also gives a basic idea about geomorphology, geomorphologic processes and associated landforms.

**(iii) Skills to be learned**

Students will learn to identify, describe and classify landforms. The students will also acquire skills to study and interpret topographic maps, geomorphic models.

**(iv) The detail contents of this course**

**THEORY**

**General Geology** *Number of Lectures: 40*

**General Concepts :** Introduction to various branches of Earth Science(2), Scope of Geology and its relation to the different branches of science(1), Standard stratigraphic time scale and introduction to the concept of time in geological studies(3), Rock types(2).

General characteristics and origin of the Universe(2), Solar System and its planets(2), The terrestrial and Jovian planets(2), Meteorites and Asteroids(4), Earth in the solar system(1), Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere(6).

Major surface features of the earth – continents and ocean basins and their evolution(3), Major internal processes of the earth- Volcanism and volcanoes(3), Types and distribution of volcanoes(4), Causes of earthquake, Earthquake belts, Earthquake zones of India(5).

**Geomorphology** *Number of Lectures: 20*

Introduction to Geomorphology, Endogenic and Exogenic processes, Orogenesis (with reference to Himalaya). Surfacial Processes and geomorphology, Weathering and associated landforms, Hill slopes. (7)

Glacial, Periglacial processes and landforms, Fluvial processes and landforms, Aeolian Processes and landforms, Coastal Processes and landforms, Landforms associated with igneous activities. (10)

Morphometry of drainage basin (3)

**PRACTICAL** *Number of Practicals: 30*

**General Geology and Geomorphology**

Study of contours: Pattern of contours to indicate various topographical features (4); Interpretation of topographic maps (5); Drawing of profile and study of geomorphological features from topographic maps (9). Model study of different geomorphic features (4).

Calculating different morphometric parameters of drainage basin. (8)

***Recommended Books:***


1. Geomorphology – A.L. Bloom; *Prentice Hall of India Pvt. Ltd.*
2. A Textbook of Geomorphology – P. Dayal; *Shukla Book Depot, Patna.*
3. Essentials of Geology- Frederick K. Lutgens, Edward J. Tarbuck and Dennis Tasa, *Prentice Hall*.
4. Geomorphology – S. Singh; *Prayag Pustak Bhawan, Allahabad*
5. Physical Geology – R. F. Flint and J Skinner, *John Wiley and Sons, Inc*
6. Textbook of Physical Geology- G. B. Mahapatra, *CBS Publishers*.
7. Principles of Geomorphology – W. D. Thornbury; *John Wiley and Sons, Inc*
8. Engineering and General Geology – P. Singh (6th edition); *S. K. Kataria and Sons*


**PAPER: GLY 102C (Crystallography & Crystal Chemistry)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**

After studying this course the student will be able to:

**CO1** Study the basics of crystallography that helps in understanding and building the overall knowledge in Geology specially the branch of mineralogy.
**CO2** Link how the internal atomic structure of minerals affects the external development of a crystal in terms of crystal symmetry, crystal system and crystal forms.
**CO3** Classify minerals into crystal systems based on crystal symmetry.

**CO4** Relate crystal chemistry and chemical bonding to the formation of minerals like crystal structure, chemistry, chemical composition.

**(ii) Broad contents of the course**

The course deals with the study of crystals with respect to their morphology, and symmetry of the crystal classes as well as internal structure of the crystal.

The course deals with the study of the principles of chemistry behind crystals and their use in describing the chemical and physical properties of crystals.

**(iii) Skills to be learned**

The students will be familiarizing themselves with crystal mophophological features, symmetry and forms as well as the internal structure of the crystal. They will be able to do the projection of crystal faces and determination of axial ratio

The students will be taught the basic concepts of chemical bonding, ionic size and ionic charge and their role in governing the physical and chemical properties of crystals

**(iv) The detail contents of this course**

**THEORY**

**Crystallography :** *Number of Lectures: 40*

Definition of crystalline and amorphous substance; Crystallization and crystal growth. (2)

Crystal morphology – faces, edges and solid angle; Interfacial angle and its measurement; Symmetry operations and elements; Types of external symmetry shown by the crystals; Point Groups; Symmetry notations of Hermann-Mauguin with relation to different crystal systems and conversion to total symmetry. (10)

Crystallographic axis; Axial ratio and its determination; Parameters and indices; Crystal forms and habit; Zone, Zone axis and Zonal equation. (6)

Unit cell; Definition and types of lattices; Significance of the lattice; Bravais (Space) lattices; Skew axis and Glide planes; Space Groups. (6)

Study of 32 Point Groups (Crystal classes) including forms, symmetry elements, stereogram and example of minerals. (8)

Crystal intergrowth; Definition of twinning, Twin elements, Composition surface, Types of Twinning, Twin laws, Study of twin laws of minerals in different crystal systems. (6)

Concept of spherical and stereographic projection.(2)

**Crystal Chemistry :** *Number of Lectures: 20*

Ionic properties- chemical bond, size, ionic charge; Electronegativity; Ionization potential; Compositional classification of minerals into groups; Elementary concepts of isomorphism; Atomic substitution; Polymorphism; Solid solution; Exsolution; Defect lattice; Packing and density; Radius ratio and co-ordination number; Pauling's rule.

**PRACTICAL** *Number of Practicals: 30*

**Crystallography :**

Study of the forms and symmetry elements of crystals belonging to the holohedral (Normal) classes of Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic & Triclinic systems and Hextetrahedral, Diploidal, Gyroidal, Tetragonal-scalenohedral, Hexagonal-Trapizohedral, Hexagonal–scalenohedral & Trigonal–trapezohedral classes with the help of either natural crystals or wooden and glass models; Drawing of crystals in clinographic projections.(15)

Study of twinning with the help of crystal models with reference to composition plane, twin plane and twin axis. (5)

Stereographic projection and determination of axial ratios of crystal models of the holohedral classes of Isometric, Tetragonal, Orthorhombic and Monoclinic systems.(10)

***Recommended Books:***


1. Manual of Mineralogy (After J.D. Dana) – C. Klein and C.S. Hurlbut, Jr.; *John Wiley and Sons, Inc*.
2. Mineralogy – Dexter Perkins; *PHI Learning Pvt. Ltd*.
3. Mineralogy – L.G. Berry and B. Mason (Revised by R.V. Dietrich); *CBS Publishers and Distributors*.
4. A Textbook of Mineralogy – E.S. Dana (Revised by W.E. Ford); *New Age International Publishers*.
5. Mineral Science – K. Conelis; *John Wiley & Sons, Inc*.
6. An Introduction to Crystal Chemistry – R.C. Evans; *Cambridge Univ. Press*.
7. Introduction to Mineral Sciences – A. Putins; *Cambridge Univ. Press*.


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**PAPER: GLY 103G (Essentials of Geology)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Tutorial classes (*Tutorials*) : 30 (60 hours)

**(i) Course learning outcome**

On completion of the course the students will be in a position to appreciate:

**CO1** The scope of the subject Geology as a whole, and its place among other branches of physical sciences.

**CO2** Understand the basic parameters and types of the planetary processes.

**CO3** The unique set of physico-chemical parameters that conditioned Earth as the only (known) life sustaining planet.

**CO4** The key structure of Earth-like planets.

**(ii) Broad contents of the course**

This foundation course is designed to provide a basic idea of the different domains of geoscience and their importance to scientifically evaluate the planetary processes. The paper will give students the scope to understand how a planet and other celestial bodies evolve from cosmic dust. More critically it will discuss the exclusive evolutionary track of Earth in terms of planetary processes and how these events allowed origin and growth of life.

**(iii) Skills to be learned**

The students will have a preliminary idea on: a) important physical parameters of the two groups of planets, b) internal structure of planets, c) how continents, oceans, mountains form, d) origin of life, e) use of radioactive method for geological dating.

**(iv) The detail contents of this course**

**THEORY** *Number of Lectures : 60*

Introduction to geology, scope, sub-disciplines and relationship with other branches of sciences. (4)

Earth- Its origin, size, shape, mass, density, rotational and evolutional parameters; Solar System- Introduction to Terrestrial and Jovian Planets; Internal constitution of the Terrestrial planets- core, mantle and crust& their sub-divisions. (20)

Origin and composition of hydrosphere and atmosphere, Origin of biosphere, Origin of oceans, continents and mountains. (15)

Geological time scale; Age of the earth; Radioactivity and its application in determining the age of the Earth; Principles of stratigraphy. (15)

Evolution of life – forms of lives through geological history. (6)

**PRACTICAL** *Number of Practicals: 30*

Study of major geomorphic features and their relationships with outcrops. (5)
Study of topographic sheets and preparation of physiographic description of an area.(5)
Determination of dip and strike from borehole data. (5)
Solution of three point problems.(5)
Study of soil profile of any specific area.(5)
Study of distribution of major lithostratigraphic units on the map of India.(5)

***Recommended Books:***


1. Holmes' Principles of Physical Geology. 1992. Chapman & Hall.
2. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press
3. Clarkson, E. N. K., 2009. Invertebrate palaeontology and evolution. John Wiley & Sons.
4. Ragan, D. M., &Ragan., 1973. Structural geology. New York: Wiley.

## SECOND SEMESTER

**PAPER: GLY 201C** **L+T+P=4+0+2= 6 credits**
**Mineralogy**
**Mineralogy Practical**

**PAPER: GLY 202C** **L+T+P=4+0+2= 6 credits**
**Geochemistry**
**Optical Mineralogy**
**Optical Mineralogy Practical**

**PAPER: GLY 203G** **L+T+P=4+0+2= 6 credits**
**Rocks and Minerals**
**Practical**

**PAPER: GLY 201C (Mineralogy)** **L+T+P=4+0+2= 6 credits**
Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**
After studying this course the student will be able to:

**CO1** Explain what is a mineral and its formation.

**CO2** Describe the physical properties of minerals.

**CO3** Gain knowledge on the minerals constituting different rock types and identify the minerals based on their physical properties.

**(ii) Broad contents of the course**
The fundamentals of mineralogy are covered in this course, which include the major groups of minerals as well as their distinguishing properties.

**(iii) Skills to be learned**
From this course, students will be able to identify different rock–forming minerals in hand specimen based on their distinguishing physical properties.

**(iv) The detail contents of this course:**

**THEORY**

**Mineralogy :** *Number of Lectures: 60*

Scope of Mineralogy: Definition of mineral; Physical properties of mineral; Relationship of physical properties with atomic structure; Mineral Classification; Structure of silicate minerals. (15)

Study of physical & optical properties, atomic structure and chemistry of the following groups of mineral – Olivine, Garnet, Epidote, Pyroxene, Amphibole, Mica, Clay minerals, Silica, Feldspar and Feldspathoid. (30)

Study of the following individual minerals – Sillimanite, Kyanite, Andalusite, Staurolite, Apatite, Chlorite, Zircon, Beryl, Calcite, Tourmaline, Magnetite, Ilmenite, Hematite, Sphene, and Rutile. (15)

**PRACTICAL** *Number of Practicals: 30*

Study of physical properties of minerals in hand specimen:
Silicates: Olivine, Garnet, Andalusite, SilIimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Zeolite . (10)

Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock crystal. (10)

Native Metals/non-metals: Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite, Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite. (10)

***Recommended Books:***


1. Mineral Science – Cornelis Klein, *John Wiley and Sons*.
2. Mineralogy – Dexter Perkins, *Pearson*.
3. Manual of Mineralogy – C. Klein and C. S. Hurlbut, *Wiley*.
4. Introduction to Mineralogy – William D. Nesse, Oxford Univ. Pr.


**PAPER: GLY 202C (Geochemistry and Optical Mineralogy)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**

After studying this course the student will be able to:

**CO1** On completion of the Geochemistry course the students will have gained an understanding about the chemical processes that operate within and upon the Earth, both present and in the past.

**CO2** Develop an understanding of the chemical nature of earth and other planetary material.

**CO3** To relate mineralogy, geochemistry and bulk chemistry.

**CO4** The Optical mineralogy course will enable students to gain knowledge on the optical properties of the minerals constituting different rock types.

**CO5** Identify the minerals based on their optical properties.

**(ii) Broad contents of the course**

The Geochemistry course is designed to give them a preliminary idea about the natural earth materials and how their chemistry can be used to understand the chemical processes of the Earth.

The Optical Mineralogy course is designed to give the students the knowledge about the optical properties of minerals, particularly rock forming minerals and how petrological microscopes can be used to identify minerals constituting the rocks.

**(iii) Skills to be learned**

The students will have a preliminary idea on major, trace, rare earth elements, radiogenic and non-radiogenic isotopes and their applications in earth sciences.

The students will have idea about the optical properties of rock forming minerals and also learn the skills to identify minerals under the petrological microscope based on minerals' optical properties.

**(iv) The detail contents of this course**

**THEORY**

**Geochemistry** *Number of Lectures: 20*

Concepts of geochemistry
Introduction to properties of elements: The periodic table; Chemical bonding
Geochemical classification of elements; Cosmic abundance of elements; The Earth in the solar system; The formation of solar system; Composition of meteorites and lunar rocks

Geochemistry of solid Earth and its reservoirs
Chemical differentiation of the earth; Composition of crust, mantle and core of the earth;

Composition of the bulk silicate Earth; Composition of seawater; Composition and evolution of atmosphere; Geochemical cycle

Isotope geochemistry
Nuclides and radioactivity
Conservation of mass, isotopic and elemental fractionation
Concept of radiogenic isotopes in geochronology and isotopic tracers

Concept of partition coefficient, camouflage, capture and admittance; Preliminary idea on major, trace and rare earth elements

**PRACTICAL** *Number of Practicals: 10*

Types of geochemical data analysis and interpretation of common geochemical plots. Geochemical variation diagrams and its interpretations.

***Recommended Books:***


1. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
2. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
3. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
4. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
5. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications,Wiley India Pvt. Ltd


## Optical Mineralogy

*Number of Lectures: 40*

Scope & utility of optical mineralogy; Reflection and refraction of rays; Refractive index; Dispersion of light; Polarization of light (*plane or linear polarization, circular polarization & elliptical polarization*); Polarizer; Linear or plane polarization by doubly refracting crystals ( *Nicol prism*), by differential absorption (*Polaroid*) and by reflection (*Brewster's Law*); Isotropic and anisotropic media. (3)

Isotropic and Anisotropic (Uniaxial positive & negative and Biaxial positive & negative) minerals; Optic axis; Optical Indicatrix : Isotropic, Uniaxial & Biaxial indicatrices, their configuration and different sections within these indicatrices.
Opaque and non-opaque minerals; Petrological (refraction or transmitted-light) and Ore (reflection-light) microscope and their configuration; Orthoscopic and conoscopic arrangement of Petrological microscope; Accessory plates (*Mica Plate*, *Gypsum Plate* & *Quartz Wedge*) & their uses. (10)

Properties of minerals in thin section : Colour; Pleochroism; Determination of pleochroic scheme; Relief; Shape or Form; Cleavage; Fracture; Double refraction; Birefringence; interference colour. (10)

Determination of refractive index of minerals [*Liquid immersion method*, *Central illumination method* (*Becke Test*) & *Oblique illumination method*]; Extinction positions; Extinction angle (*straight* or *parallel*, *oblique* & *symmetrical extinction*); Interference colour & its determination; Determination of vibration direction. (10)

Different types of Uniaxial and Biaxial Interference figures; Determination of optic sign; Measurement of optic axial angle. (5)

Distinguishing Optical Characters of Some Important Non-opaque minerals: Garnet group (*Garnet*); Olivine group (*Olivine*); Aluminosilicate group (*Sillimanite*, *Kyanite*, *Andalusite*); *Serpentine*; *Staurolite*; Pyroxene group (*Enstatite*, *Hypersthene*, *Augite*, *Diopside*); Amphibole group (*Actinolite*, *Hornblende*); Mica group (*Biotite*, *Muscovite*); Feldspar group [*Orthoclase*, *Microcline*, *Plagioclase*(*Albite* to *Anorthite*)]; Feldspathoid group (*Nephelene*, *Leucite*) and Silica group (*Quartz*); Carbonate minerals (*Calcite*, *Dolomite*). (2)

**PRACTICAL** *Number of Practicals: 20*

**Optical Mineralogy**

Study & Identification of the following minerals in thin section under Petrological Microscope :

Minerals with high to moderate relief: Garnet group (***Garnet***); Olivine group (***Olivine***); Alumino-silicate group (***Sillimanite***, ***Kyanite***, ***Andalusite***); ***Serpentine***; ***Staurolite***; Pyroxene group (***Enstatite***, ***Hypersthene***, ***Augite***, ***Diopside***); Amphibole group (***Actinolite***, ***Hornblende***); Mica group (***Biotite***, ***Muscovite***). (7)

Minerals with low relief: Feldspar group (***Orthoclase***, ***Microcline***, ***Plagioclase***); Feldspathoid group (***Nephelene***, ***Leucite***) and Silica group (***Quartz***). (2)

Minerals with variable relief : Carbonate minerals (***Calcite***, ***Dolomite***). (1)
Comparison of the refractive index of mineral in thin section with the help of central illuminationmethod (Becke Test). (1)

Determination of the composition of plagioclase by Michael-Levy method. (2)

Study under Petrological Microscope of uniaxial and biaxial interference figures and their recognition. Determination of optic sign from centered & off-centered uniaxial interference figures and centered acute bisectrix & centered optic axis biaxial interference figures by the use of accessory plates. (7)

***Recommended Books:***

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1. Optical Mineralogy: Principles and Practice – Colin D. Gribble and Allan J. Hall, *George Allen and Unwin, 1985*.
2. Optical Mineralogy – P.F.Kerr; *McGraw-Hill Book Company, INC*.
3. Fundamentals of Optical, Spectroscopic and X-ray Mineralogy – S.Mitra; *New Age International Publishers*.
4. Optical Mineralogy: The Nonopaque Minerals – W.R.Phillips and D.T.Griffen; *CBS Publishers and Distributors*.
5. Optical Crystallography – E.E.Wahlstrom; *John Wiley and Sons, Inc.*
6. An Introduction to the Rock-Forming Minerals – W.A.Deer, R.A.Howie and J.Zussman; *ELBS Publishers with Longman*.


**PAPER: GLY 203G (Rocks and Minerals)** **L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

(i) **Course learning outcome**:
After studying this course the student will be able to:

**CO1** Acquainted with different types of rocks and minerals along with crystal systems.

**CO2** Know veracity of geological processes and formation of different rock types.

**CO3** Understand the structure of the Earth and distribution of rocks

**(ii) Broad contents of the course**
Petrology is the science of rocks. The course will help the students to exhibit an improved understanding of fundamental petrologic processes and common rock types.

**(iii) Skills to be learned**
Students learn to identify, describe and classify rocks using hand specimens. The students will also acquire skills to determine and interpret the mineralogy of rocks.

**(iv) The detail contents of this course**

**THEORY**

**Mineralogy** Number of Lectures:16

Crystallography: Crystalline and amorphous substance, Morphological features of crystal, External symmetry of crystal, Crystallogaphic axis, Axial ratio, Parameter and Indices, Crystal forms and habit.
Crystal system and class, Study of the normal classes of Isometric, Tetragonal, Hexagonal and Orthorhombic system. (5)

Descriptive Mineralogy: Scope of Mineralogy: Definition of mineral; Physical properties of mineral; Relationship of physical properties with atomic structure; Mineral Classification; Structure of silicate minerals.
Study of physical & optical properties, atomic structure and chemistry of the following groups of mineral – Olivine, Pyroxene, Amphibole, Mica, Silica, Feldspar
Study of the following individual minerals – Sillimanite, Kyanite, Andalusite, Zircon, Beryl, Calcite, Tourmaline, Magnetite, Hematite and Rutile. (5)
Optical Mineralogy: Scope of optical mineralogy; Nature of light, Wave front and wave surface, Isotropism/Anisotropism, Pleochroism, Refractive index – its determination, Polarization of light, Double refraction, Uniaxial & biaxial minerals, Extinction in minerals, Interference colour, Relief, Nicol prism, Polarizing microscope. Optical properties of minerals in conoscopic light. (6)

**Igneous Petrology** Number of Lectures: 16

Igneous rocks; Mode of occurrence of igneous rocks; Textures and structures; Classification of igneous rocks on textural, mineralogical (IUGS classification) and quasi-chemical (CIPW) criteria.
Magma: composition, origin and types; Crystallization of magma; Bowen's reaction series; Magmatic differentiation. (8)
Mineralogical phase rule; phase equilibria in igneous rocks: one and two component systems (Silica system, Diopside-Anorthite system and Forsterite-Silica system). (4)
Brief petrographic discussion of the following rock types- Granite, Rhyolite, Gabbro, Basalt, Andesite, Syenite and Pegmatite. (4)

**Metamorphic Petrology** Number of Lectures: 16

Metamorphic Geology, Definition of metamorphism and metasomatism, Factors or agents of metamorphism, Types of metamorphism. Prograde (Barrovian zones) and retrograde metamorphism. Basic concepts of depth zones, grades and facies classification of metamorphic rocks. Textures and structures of metamorphic rocks. (8)
Nomenclature of metamorphic rocks: Foliated and lineated rocks – slate, phyllite, schist, and gneiss.
Non-foliated and non-lineated rocks – Hornfels. Specific types – marble, quartzite, greenschist, amphibolites, serpentinite, blueschist, eclogite, granulite, migmatite. (8)

**Sedimentary Petrology** Number of Lectures: 12

Introduction; Abundance of common sediments; Processes of formation of sedimentary rocks; Mineralogicalcomposition of sedimentary rocks. (2)
Textures of sedimentary rocks. (3)
Sedimentary structures: lamination, ripple marks, current bedding, graded bedding, mud cracks, rain drop imprints. (2)
Classification of sedimentary rocks; Petrographic description of sandstone and limestone. (3)
Concept of sedimentary environment. (2)

**PRACTICAL** Number of Practical: 30

**Crystallography** No. of class: 10

Study of the models of the crystal forms of the normal classes of Isometric, Tetragonal, Hexagonal and Orthorhombic system.

**Mineralogy** No. of class: 10

Study of the distinguishing physical properties of important minerals in hand specimen.
Study of the following minerals in thin section under Petrological Microscope: Olivine, Augite, Hornblende, Muscovite, Biotite, Orthoclase, Microcline, Plagioclase, Quartz.

**Igneous Petrology** No. of class: 3

Identification of common igneous rock hand specimens.

**Metamorphic Petrology** No. of class: 3

Identification of the following metamorphic rock hand specimens:
Slate, phyllite, schists, gneiss, quartzite, marble, amphibolite, granulite, augen gneiss, migmatite.

**Sedimentary Petrology** No. of class: 4

Identification and study of the following rocks in hand specimens: Conglomerate, Breccia, Grit, Sandstone, Shale, Limestone.
Identification and study of following sedimentary structures: Lamination, Ripple marks, Current bedding, Geode & Concretion.

***Recommended Books:***


1. Klein, C. & Philpotts, A. (2013). Earth Materials- Introduction to Mineralogy and Petrology, Cambridge University Press.

2. Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts, Cambridge University Press, 2013.

3. Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and company, New York.

## THIRD SEMESTER

**PAPER: GLY 301C** **L+T+P=4+0+2=6 credits**
**Structural Geology**
**Structural Geology Practical**

**PAPER: GLY 302C** **L+T+P=4+0+2= 6 credits**
**Igneous Petrology**
**Igneous Petrology Practical**

**PAPER: GLY 303C** **L+T+P=4+0+2= 6 credits**
**Sedimentary Petrology**
**Geotectonics**
**Sedimentary Petrology Practical**

**PAPER: GLY 304G** **L+T+P=4+0+2= 6 credits**
**Physics and Chemistry of Earth**
**Practical**

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**PAPER: GLY 301C (Structural Geology)** **L+T+P=4+0+2= 6 credits**
Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**

After studying this course the student will be able to:

**CO1** Deal with geological structures resulting from the action of forces on rocks.

**CO2** Gain knowledge about the deformation mechanism of the rocks.

**CO3** Gain knowledge of the geometry of the rock structures

**CO4** Understand the mechanism of the evolution of rock structures and its application in the field.

**(ii) Broad contents of the course**

The course is designed for the students to understand the geometry and mechanics of the various geological structures that result through the deformative processes operative within the earth.

**(iii) Skills to be learned**

The students learn the skills of identifying different structure and measurements using Clinometer and Brunton compass. This is fundamental to geological mapping. This course also helps to know how to use structures and help students appreciate the dynamic nature of the Earth lithosphere. Learn how to read geologic maps and solve map problems using strike and preparations of cross sections, stereographic projection of geological structures and some other structural problems.

**(iv) The detail contents of this course**

**THEORY**

**Structural Geology** *Number of Lectures: 60*

**Introduction**
Geometric, kinematic and dynamic analysis of rock structures; Penetrative and non-penetrative structural elements; Scales of observation: time & length; Structural Elements and their attitudes; Concept of non-diastrophic and diastrophic structures. (5)

**Primary structures**
Primary structures in sedimentary rocks: bedding & stratification, primary structures as markers and facing/younging direction, recognition of bedding in deformed terrains; Penecontemporaneous structures; Primary structures in igneous rocks; Unconformities. (5)

**Physics of deformation**
*Analysis of Stress*: Concept of Force, Traction & Stress, Stress components, Stress at a point, Principal axes of stress & principal stresses, Stress ellipsoid; Elementary concept of Mohr's stress circle, Terminology of states of stress: Hydrostatic stress, Uniaxial compression & -tension, Axial compression & -extension, Triaxial stress, Pure shear & Simple shear, Deviatoric stress, Differential stress, Effective stress.
*Analysis of strain*: Strain & Strain ellipsoid; Measure of strain- longitudinal and shear strain; Homogeneous & Inhomogeneous Strain; Finite & Infinitesimal strain; Special type of Homogeneous (finite) strain: Plane strain, constriction, & flattening; Pure shear & simple shear.
*Deformational behaviour of rocks*: Elementary concept of rheology, Basic rheological models: Viscous, Elastic, Plastic; Controls of time, temperature and pressure on deformation. (15)

**Rock Fabrics in deformed rocks**
Concept of pervasive (material) and non-pervasive (non-material) fabrics; Tectonites.
*Lineation***:** Morphological types of lineation: Discrete structural lineation, Constructed structural lineation, Mineral lineations, slickenlines & slickensides, Rods, Mullions.
*Foliation:* Cleavage; Morphological types of foliation: Axial planar foliation, Compositional foliation, Disjunctive foliation, Crenulation foliation, Continuous foliation, Transected foliation.
Role of fabric elements in structural interpretations of deformed rocks. (5)

**Brittle Deformation in Rocks**

*Fractures & Joints*: Types of fractures: Extension, Shear fracture; Modes of fracture; Feature of fracture surfaces; Classification of joints; Origin of joints.

*Faults*: Terminology of faults; Rocks associated with faults; Structural elements of faults; Classification & Types of faults; Characteristics & Structural Associations: Normal fault, Reverse (Thrust) fault, and Strike-slip fault; Anderson's classification of faults; Recognition of faults in field.

*Boudinage*: Types of boudins; Geometrical parts of boudin; Pinch-and-swell Structure. (15)

**Ductile Deformation in Rocks**

*Folds*: Geometrical parts of single folded layer & multilayer folded surface; Structural elements of folds; Morphological classification of folds (after Ramsay, 1967); Types of folds. (15)

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**PRACTICAL** *Number of Practicals: 30*

1. Introduction to structural elements: Structural lines & Structural planes. (1)
2. Graphical method for structural solution. (3)
3. Analysis of bore hole data: Thickness and depth of planes; Solution of three-point problems. (1)
4. Geological Maps: Completion of outcrops of beds from surface and borehole data; Drawing of cross-section & Interpretation of structures from geological maps. (10)
5. Stereographic projection: Plotting of i) lines, ii) planes, iii) poles to the planes; Determination of i) attitude of the line of intersection between two planes, ii) angle between two planes, iii) apparent dip(s) in different directions in a plane, iii) strike & true dip from apparent dip(s); Stereo-plot of some different folds. (10)
6. Determination of fault displacement. (1)
7. Exercise on Mohr's Stress Circle: Determination of (i) principal stresses from normal and shear stresses & ii) the normal and shear stresses from the principal stresses and their directions. (1)
8. Plot of different stress types on Mohr's circle. (1)
9. Calculation of Finite Strain from deformed fossils, grains and pebbles. (2)

***Recommended Books:***


1. Foundation of Structural Geology (1997) – R.G. Park; *Routledge*.
2. Structural Geology- Fundamentals & Modern Developments (1993) – S.K. Ghosh; *Pergamon Press*.
3. Folding and fracturing of rocks (1967) – J.G. Ramsay; *McGraw-Hill*.
4. Structural Geology (2007) – R.J. Twiss and E.M. Moores; *W.H. Freeman and Company*.
5. An outline of Structural Geology (1976) – B.E. Hobbs, W.D. Means & P.F. Williams; *John Wiley*.

6. Structural Geology of Rocks and Regions (2011) – G.H. Davis; *John Wiley*.
7. Structural Geology (2010) - Haakon Fossen; *Cambridge University Press*.
8. Structural Geology (1973) – M.P. Billings; *Pearson College*.

**PAPER: GLY 302C (Igneous Petrology)** **L+T+P=4+0+2= 6 credits**
Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**

On completion of the course the students will be able to:

**CO1** Understand the processes involved in the formation of igneous rocks, their textures and structures.

**CO2** Classify of igneous rocks and their importance.

**CO3** Understand of the types of magma as well as types of igneous rocks.

**CO4** Determine the evolution of igneous rocks using petrographical, mineralogical and geochemical indices.

**CO5** Describe magmatic rocks from a plate tectonic point of view.

**(ii) Broad contents of the course**
Igneous petrology is the study of magmatic rocks. The course will help the students to exhibit an improved understanding of fundamental magmatic processes and common igneous rock types.

**(iii) Skills to be learned**
Students learn to identify, describe and classify igneous rocks using hand specimens. The students will also acquire skills to identify minerals and textures under the microscope and classify igneous rocks on the basis of microscopic observations.

**(iv) The detail contents of this course**

**THEORY**

**Igneous Petrology :** *Number of Lectures: 60*

Concepts of Igneous petrology
Introduction to petrology: Heat flow, geothermal gradients through time, origin and nature of magma

Forms
Classification of igneous rocks
Textures and structures of igneous rocks
Mode of occurrence of igneous rocks

Phase diagrams and petrogenesis
Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas
Magma generation in crust and mantle, their emplacement and evolution

Magmatism in different tectonic settings
Magmatism in the oceanic domains (MORB, OIB)
Magmatism along the plate margins (Island arcs/continental arcs)

Petrogenesis of Igneous rocks
Petrogenesis of Felsic and Mafic igneous rocks
Komatiites, Granitoides, Basalt, Gabbros
Alkaline rocks, kimberlites and lamproites.

**PRACTICAL** *Number of Practicals: 30*

Study of important igneous rocks in hand specimens and thin sections- granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite

***Recommended Books:***


1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation.Routledge.
4. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
6. Myron G. Best (2001). Igneous and Metamorphic Petrology,
7. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
8. Bose M.K. (1997). Igneous Petrology.
9. G W Tyrrell. (1926). Principles of Petrology. Springer

**PAPER: GLY 303C (Sedimentary Petrology and Geotectonics)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

(i) **Course learning outcome**

After studying this course the student will be able to:

**CO1** Learn different kinds of sedimentary rocks, their structures, textures and variability.

**CO2** Understand of sedimentation process from deposition to diagenesis.

**CO3** Understand the different types of sedimentary environments.

**CO4** Appreciate the dynamic nature of the Earth processes.

**CO5** Learn the geodynamics of the lithosphere and concept of isostacy, ocean floor spreading, continental drift, plate tectonics.

(ii) **Broad contents of the course**

Sedimentary petrology is that particular branch of study concerned especially with the composition, characteristics and origins of sediments and sedimentary rocks. It focuses on the physical, chemical and biological characteristics of the principal kinds of sedimentary rocks; however, it is concerned also with the relationship of these properties to depositional conditions and provenance.

Geotectonics course develops the concepts of plate tectonics on a global scale and analyses the physical processes responsible for the formation and destruction of the plates.

(iii) **Skills to be learned**

The student will learn how to use precise geological terms in describing and discussing sedimentary structures, textures and processes and identify the main types of sedimentary rocks such as mudstones, sandstones, conglomerates, limestones and evaporites interpret sedimentary processes based on the composition of the rock and sedimentary structures identify the depositional environments.

The student will be introduced to the structure of the continental crust vs. oceanic crust and their geodynamic. They will also appreciate the modern concept of plate tectonics and its implications.

**(iv) The detail contents of this course:**

**THEORY**

**Sedimentary Petrology :** *Number of Lectures: 40*

Introduction; Scope and purpose; Processes of formation of sedimentary rocks: Weathering, erosion, transportation, deposition and diagenesis; Abundance of common sediments; Mineralogical composition of sedimentary rocks; Provenance; Sedimentary cycle; Physico-chemical factors of sedimentation. (10)

Textures of sedimentary rocks: concepts of size, grade scale, sphericity, roundness, fabric, packing, porosity and permeability; grain size analysis and their implications. (10)

Sedimentary structures and their significance: Mechanical, chemical and biological.(5)

General classification of sedimentary rocks; Descriptive petrography of fundamental rock types: conglomerate, breccia, sandstone and limestone. (10)

Basic ideas of depositional environments and their classification. (3)

Concepts of facies and facies association. (2)

**Geotectonics** *Number of Lectures: 20*

Introduction; Internal structure of the earth; Classical concepts of Geosynclines; Concepts of Isostasy; Historical perspective of plate tectonics. (5)
Continental drift hypothesis; Palaeomagnetism, Sea floor spreading and plate tectonics; Divergent plate boundaries; Convergent plate boundaries; Obduction principle and emplacement of ophiolites; Evolution of Himalayas and structure and tectonics of Himalayan mountain belt; Transform fault boundaries. (10)
Triple point junctions; Mantle plumes and hotspots; Seismic belts of the world; Mechanism of plate tectonics; Plate movement over geologic time; Structure and tectonics of North-eastern India. (5)

**PRACTICAL** *Number of Practicals: 30*

Identification and study of the clastic and nonclastic rocks in hand specimens. (5)
Particle size distribution and statistical treatment. (5)
Exercises on sedimentary structures. (5)
Identification & study of quartz types, limestone and heavy minerals in thin sections. (15)

***Recommended Books:***


1. Sedimentary Petrology by F. J. Pettijohn; *CBS Publishers and Distributors*.
2. Introduction to Sedimentology by S. M. Sengupta; *CBS Publisher & Distributors*.
3. Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks by M. E. Tucker; *Blackwell Science.*
4. Sedimentology and Stratigraphy by G. Nichols; *Wiley and Blackwell*.

5. Depositional Sedimentary Environments by H. E. Reineck & I. B. Singh; *Springer*.
6. Sedimentary Rocks in the Field by M. E. Tucker; *John Wiley & Sons Ltd*.
7. Geotectonics – V.V. Beloussov; *Springer Berlin Heidelberg*
8. Plate Tectonics and Crustal Evolution – K.C. Condie; *Pergamon Press*
9. Seismology and Plate Tectonics – D. Gubbins; *Cambridge University Press*
10. Plate Tectonics – R.L. Johnson; *Twenty–First Century Books*
11. Global Tectonics – P. Keary & F.J. Vine; *Blackwell Scientific Publications*
12. Plate Tectonics – S.M. Tomecek; *Infobase publishing*
13. Aspects of Tectonics – K.S. Valdiya; *Tata McGraw-Hill Publishing Company Ltd*.
14. The Evolving Continents – B.F. Windley; *John Wiley and Sons, Inc*.
15. Geodynamics of Northeastern India and the adjoining region – D.R. Nandy; *acb publications*

**PAPER: GLY 304G (Physics and Chemistry of Earth) L+T+P=4+0+2= 6 credits**
Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**
After studying this course the student will be able to:

**CO1** Understand about the physical and chemical processes that operate within and upon the Earth, both present and in the past.

**CO2** Know the dynamism in Earth processes.

**CO3** Have an idea about nucleosynthesis and elemental distribution in the Earth.

**CO4** Appraise of concepts of Earth's magnetism.

**(ii) Broad contents of the course**
The course is designed to give them a preliminary idea about the natural earth materials and how their chemistry can be used to understand the chemical processes of the Earth. The students will have a preliminary idea on radiogenic and non-radiogenic isotopes and their applications in earth sciences.

**(iii) Skills to be learned**
The students will have a preliminary idea on the origin of elements and their geochemical classification. They will learn to classify and characterize rocks from major element data by using different geochemical plots.

**(iv) The detail contents of this course**

**THEORY**

Earth: surface features- Continents, continental margins, oceans.

Earth's interior –theory of stress & strain;variation of physical quantities; Seismological and other geophysical constraints; Seismic wave velocity inside the earth; major sub divisions and discontinuities.

Concepts of Isostasy- Airy & Pratt Model; Continental drift; Plate tectonics- Sea Floor spreading, Palaeomagnetism; Types of plate boundaries; Different Forces for driving plates.

Internal structure of the Earth, Convection in the Earth's mantle& Core, mantle plume, Geodynamo, Secular variation.

Elements: Origin of elements/nucleosynthesis. Abundance of the elements in the solar system / planet earth Geochemical classification of elements. Earth accretion and early differentiation Isotopes and their applications in understanding Earth processes. Stable isotopes: Stable isotope fractionation. Oxygen isotopes Sublithospheric Mantle (Mineralogy/phase transitions).

**PRACTICAL** *Number of Practicals: 30*

Projection of major elements on binary and triangular diagrams for rock classification

Projection of major element data on Harker's diagram to characterize magmatic differentiation

Understanding Earth structure through behavior of seismic wave propagation

Study of seismic profile of a specific area and its interpretation.

Problems on isostasy.

***Recommended Books***


1. Holmes, A., Principles of Physical Geology, 1992, Chapman and Hall.
2. Condie, K.C. Plate Tectonics and Crustal Evolution, Pargamon Press, 1989.
3. Krauskopf, K. B., & Dennis, K. Bird, 1995, Introduction to Geochemistry. McGraw-Hill
4. Faure, G. Principles and Applications of Geochemistry, 2/e (1998), Prentice Hall, 600 pp.
5. Anderson, G. M. (1996). Thermodynamics of natural systems. John Wiley & Sons Inc.
6. Steiner, E. (2008). The chemistry maths book. Oxford University Press.
7. Yates, P. (2007) Chemical calculations. 2nd Ed. CRC Press.

## FOURTH SEMESTER

**PAPER: GLY 401C** **L+T+P=4+0+2= 6 credits**
**Metamorphic Petrology**
**Metamorphic Petrology Practical**

**PAPER: GLY 402C** **L+T+P=4+0+2= 6 credits**
**Principles of Stratigraphy**
**Geological Field Work - I**

**PAPER: GLY 403C** **L+T+P=4+0+2= 6 credits**
**Indian Stratigraphy**
**Seminar and Home Assignment**

**PAPER: GLY 404G** **L+T+P=4+0+2= 6 credits**
**Earth Surface Processes and Landforms**
**Practical**

**PAPER: GLY 401C (Metamorphic Petrology)** **L+T+P=4+0+2= 6 credits**
Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Coarse Learning outcome**

After the completion of this course students will be able to:

**CO1** Understand metamorphic rocks, metamorphism and metamorphic processes.

**CO2** Understand the aspects of metamorphic transformation and the role of P, T and chemically active fluid in controlling the changes in different types of metamorphism.

**CO3** Understand nature of metamorphic rocks in contrast to igneous and sedimentary rocks

**CO4** Apply phase rule as a basic tools in study of these rocks and through learning control of bulk composition on assemblage development.

**CO5** Plot the quantitative as well as qualitative mineral and mineral assemblage data to interpret the discontinuous reactions and to infer the nature of continuous reactions

**(ii) Broad content of the course**

The course imparts ideas on the aspects of metamorphic transformation and the role of P, T and chemically active fluid in controlling the changes in different types of metamorphism, metamorphic facies, formation of different mineral assemblages, metamorphic textures and structures.

**(iii) Skills to be learned**

Students learn to identify, describe and classify rocks using hand specimens. The students will also acquire skills to determine and interpret petrogenetic history of the metamorphic rock.

**(iv) The detail contents of this course**

**THEORY** *Number of Lectures: 60*

Concept of metamorphism: Limits of metamorphism(2), Agents of metamorphism(2), Types of metamorphism(3), Types of Protoliths(2), A preliminary classification of metamorphic rocks(2), concept of zones(2), grades and facies(2). Metamorphic textures and structures(3).

Chemical equilibrium in metamorphism: The phase rule and its application in metamorphic rocks(3). PT phase diagrams and compositional phase diagrams(3). Common chemographic diagrams(3), ACF and AKF diagrams(2).

Metamorphic reactions and its types: Polymorphic transformation, exsolution reactions, Solid - solid net transfer reactions, devolatilization reactions(4). Continuous reactions, oxidation/reduction reactions, reactions involving dissolved species(3), reactions and chemographics(3), phase diagrams for multicomponent systems(3).

Metamorphism of pelitic sediments: Diagenesis and low- grade metamorphism of pelites, medium P/T metamorphism of Pelites – The Barrovian sequence, Low P/T of metamorphism of Pelites(5), Partial melting of Pelites and migmatites(4). Metamorphic Facies and facies series(3); metamorphism of mafic rocks(2): UHT and UHP metamorphism(2). PT-t paths(2).

**PRACTICAL** *Number of Practicals: 30*

Identification of the various kinds of metamorphic rocks and identification of their textures and structures in handspecimen.
Slate, phyllite, various types of schists, gneiss, amphibolite,granulite, quartzite, hornfels, augen gneiss, calc-silicate rocks, marble, mylonite, migmatite, eclogite. (10)

Study of the textures and assemblages of metamorphic rocks in thin section to know the petrogenetic history of the rock and nomenclature of the rocks.
Chlorite schist, biotite schist, garnet schist, sillimanite schist, hornblende schist, amphibolites, granulites, eclogites and quartzites. (20)

***Recommended Books:***


1. Metamorphic Petrology – B.W.D. Yardley; *ELBS/Longman*
2. Petrology of Igneous and Metamorphic Rocks – D.W Hyndman (2nd Edition); *McGraw-Hill Book Company*
3. Igneous and Metamorphic Petrology – M.G. Best; *CBS Publishers and Distributors*
4. An introduction to igneous and metamorphic petrology - John, D Winter; *Prentice Hall*.
5. Petrology – W.T Huang; *McGraw-Hill book Company*
6. Metamorphism and Metamorphic Belts – A Miyashiro; *George Allen & Unwin Ltd*.
7. The Study of Rocks in Thin Section – W.W. Moorhouse; *CBS Publishers & Distributors.*
8. Principles of Igneous and Metamorphic Petrology – A.R. Phillpotts; *Prentice-Hall of India Pvt.Ltd.*
9. Igneous and Metamorphic Petrology – F.J. Turner and & J. Verhoogen; *McGraw-Hill book Company*.
10. Metamorphic Petrology – F.J. Turner; *McGraw-Hill book Company*.
11. Petrogenesis of Metamorphic Petrology – H.G.F. Winkler; *Springer Verlag, New York Inc*.


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**PAPER: GLY 402C (Principles of Stratigraphy & Geological Field-I)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)

**(i) Course learning outcome**

On completion of the course the students will be able to:

**CO1** Understand the fundamentals of stratigraphic principles and various methods of stratigraphic analysis.

**CO2** Understand the basic principles of interpretation of geological history based on stratal relationship.

**CO3** Understand the classification and nomenclature of rock units based on their litho, bio and chronostartigraphic characteristics.

**CO4** Deciper paleogeographic changes (distribution of land and sea) at broader scale and

incremental shift of environment, energy conditions, tectonics, climate etc. at finer scale within basin or formation level.

**CO5** Gain hands on and practical idea on the different rock types and geological structures and their measurements in the field.

**(ii) Broad contents of the course**

The course comprises the basic principles of stratigraphy and their application in the interpretation of geological history. It also elucidates the classification and nomenclature of startigraphic units on different basis.

**(iii) Skills to be learned**

After completion of this course, students will be able to interpret the stratal relationship of rock units in the field and classify them.

**(iv) The detail contents of this course**

**THEORY**

**Principles of Stratigraphy :** *Number of Lectures: 60*

A brief survey of classical geological reconnaissance. (1)
Preliminary idea of crustal and biological evolution of earth through geologic time.Different methods of measurement of geological time. (4)

Fundamentals of litho-, bio- and chrono-stratigraphy. (3)

International Stratigraphic Code – development of a standardized stratigraphic nomenclature. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP). (9)

Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy and sequence stratigraphy). (9)

Principles of stratigraphic correlation.(5)

Paleoclimate, paleogeography and eustatic changes. (5)

Principles of stratigraphic analysis. (5)

Facies concept in stratigraphy and Walther's Law of Facies. (5)

Concept of paleogeographic reconstruction. (5)

**Geological Field Work – I :** 2 credits

(a) Duration of the Fieldwork is to be of minimum 3 days.
(b) An area with good rock exposures is to be selected for this field trip.
(c) Students are to be trained how to take readings like strike direction, amount & direction of dip; plunge & bearing; front bearing & back bearing with the help of Clinometer and Brunton Compass.
(d) A Field report is to be submitted before the Fourth Semester Examination and Viva-voce to be conducted.

***Recommended Books:***


1. Stratigraphic Principles and Practices – J.M.Weller; *Universal BookStall, Delhi*.
2. Principles of Stratigraphy – C.O.Dunbar and J.Rodgers; *John Wiley and Sons, Inc*.
3. Stratigraphy and Sedimentation – W.C.Krumbein and L.L.Sloss; *W.H. Freeman*
4. Boggs, S. Jr., Principles of Sedimentology and Stratigraphy (Fourth Edition), *Prentice Hall.*


**PAPER: GLY 403C (Indian Stratigraphy and Seminar & Home Assignment)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)

**(i) Course learning outcome**

On completion of the course the students will be able to

**CO1** Have an idea on the wide range of lithologies of Indian sub-continent that span from 3.6 billion years to present.

**CO2** Gain knowledge about the stratigraphy and geology of India with respect to Precambrian, Paleozoic, Mesozoic and Cenozoic Era which will help in understanding the different episodes on the earth during the geologic past.

**CO3** Prepare and present a seminar topic assigned to them.

**CO4** Prepare home assignments given to them by respective teachers.

**(ii) Broad contents of the course:**

The course intends to introduce students to important geological formations of India, from Precambrian to Recent times.

**(iii) Skills to be learned:**

At the end of the course, the students will acquire skills that will enable to recognize different geological formation, their age and economic potential. They will also learn to correlate International Geological Time Scale with Indian Stratigraphic Time Scale.

**(iv) The detail contents of this course:**

**THEORY**

**Indian Stratigraphy :** *Number of Lectures: 60*

A brief outline of the geology of India – Precambrian to Recent. (3)

A detailed study of the Precambrian stratigraphy of India of the following with respect to lithology, tectonics, igneous activity, geochronology and economic importance : (30)
(a) Dharwar Craton; (b) Bastar Craton; (c) Singhbhum Craton; (d) Aravalli Craton; (e) Bundelkhand Craton; (f) Eastern Ghat Mobile Belt; (g) Satpura Mobile Belt or CITZ; (h) Assam-Meghalaya Plateau (*Shillong Plateau*); (i) Southern Granulite Terrain; (j) Cuddapah Supergroup of Cuddapah basin; (k) Vindhyan Supergroup of Son Valley and (l) Chhattisgarh Supergroup of Chhattisgarh basin.

A brief study of the problems of correlation of the Precambrian rocks of India. (2)

A detailed study of the Phanerozoic stratigraphy of the following areas with emphasis on the points mentioned therein : (25)
Palaeozoic of the Salt Range and Spiti – *Stratigraphic succession*, *lithology*, *palaeontology* and *age*.
Gondwana of Peninsular and Extra-peninsular India – *Classification*, *lithology*, *palaeontology*, *palaeogeography*, *igneous activity*, *structure* and *economic importance*.
Mesozoic of the Salt Range and Triassic of Spiti – *Palaeontology* and *lithology*.
Jurassic of Cutch – *Palaeontology* and *lithology*.
Cretaceous of South India, Central-Western India and NE India – *Lithology, palaeogeography, and palaeontology*.
Deccan Traps – *Distribution*, *lithology* and *age*.
Palaeogene and Neogene (Tertiary) & Quaternary of North-East India – *Lithology*, *palaeontology*, *structure* and *economic importance*.
Neogene and Quaternary of Siwalik Group – *Lithology, palaeogeography, palaeoclimate and palaeontology*.

***Recommended Books:***


1. Precambrian Geology of India – S.M.Naqvi and J.J.W.Rogers; *Oxford University Press*.
2. Indian Precambrian – B.S.Paliwal (Ed.); *Scientific Publications* (*India*), *Jodhpur*.
3. Cratons and Fold Belts of India – R.S.Sharma; *Springer-Verlag.*
4. Geology of India, Vol. 1 & 2 – M. Ramakrishnan and R. Vaidyanathan; *Geological Society of India, Bangalore*.


**Seminar:** 1 credit

(a) Each student must take part individually in seminar which includes the presentation and discussion on the seminar topic with maximum duration of 20 minutes.

(b) The tentative list of topics for Seminar shall be notified at the beginning of the semester. The students are advised to discuss with the concerned teacher and get it approved by the HOD.

(c) The students shall be required to submit the draft of the seminar topic within two weeks of the notification. The concerned teacher shall make suggestions for modification in the draft.

(d) The final write-up must be submitted by the student prior to the date of seminar presentation.

**Home Assignment** 1 credit

To be assigned by the concerned teachers on any topic related to the papers GLY 101C to GLY 403C.

**PAPER: GLY 404G (Earth Surface Processes and Landforms)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**
On completion of the course the students will be able to:

**CO1** Understand the earth surface processes and the factors affecting these processes.

**CO2** Gain knowledge on the different geologic processes and resulting landforms.

**CO3** Have an idea on the basics of planetary geomorphology

**(ii) Broad contents of the course**
This course is on the earth surface processes and the internal and external factors controlling these processes. All the important geological processes such as fluvial, glacial, aeolian and coastal along with their associated landforms are included. Other important concepts of geomorphology incorporated into the course are scales of landscape analysis, basic concepts of morphometric analysis of drainage basin, methods of measuring denudation rates; and introduction to planetary geomorphology

**(iii) Skills to be learned**
After studying the course, student will be able to interpret different geomorphic features and drainage morphometry.

**(iv) The detail contents of this course**

**THEORY**

**Earth Surface Processes and Landforms** *Number of Lectures: 60*

Introduction to earth surface processes: (10); Historical development in concepts; Scales of landscape analysis- spatial and temporal; Terrestrial relief features; Basic idea on endogenic and exogenic processes.

Energy flow in geomorphic systems and surface processes: (20); Systems concept in geomorphology; Fundamental driving forces: internal (geological) and external (climatic) forces; Weathering and formation of soils; Karst and speleology; Hill Slope; Fluvial, aeolian, glacial, and coastal processes and resulting landforms; Drainage basin and basic concepts of morphometric analysis of drainage basin.

Rates of denudation of landforms: (10); Fluvial, aeolian, and glacial denudation rates; Methods of measuring denudation rates; Climate and relief factors in denudation rates; Structure and tectonic factors in denudation rates.

Controlling factors and geomorphic response: (10); Climate change and geomorphic response; Geomorphic response to tectonics, sea level/base level change, anthopogenic affects; Introduction to anthropocene.

Geomorphic concepts in cause-effect relationship: (10); Magnitude-frequency concept, time-lag, sensitivity, equilibrium, threshold Surface processes and natural hazards; Applied aspects of geomorphology; Introduction to planetary geomorphology.

**PRACTICAL** *Number of Practicals: 30*

Interpretation of surface processes from geomorphological maps; (5)

Model study of different geomorphic features; (5)

Exercises on hill slope development, fluvial channel, sediment erosion and transport, drainage basin, drainage morphometry; (15)

Basic exercises for computation of rate for different surface processes. (5)

***Recommended Books:***

1. Bloom, A.L., 1998. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education.

2. Gregory, K. J. 2010. The Earth's Land Surface: Landforms & Processes in Geomorphology, SAGE Publication

3. Esterbrook, D.J., 1992. Surface Processes and Landforms, MacMillan Publ.

4. Kale, V.S. and Gupta A 2001 1ntoduction to Geomorphology, Orient Longman Ltd.

5. Leeder, M. and Perez-Arlucea M 2005 Physical processes in earth and environmental sciences, Blackwell' publishing.

6. Summerfield M A 1991 Global Geomorphology Prentice Hall.

7. Harvey, A. 2012. Introducing Geomorphology: A Guide to Landforms & Processes, Dunedin Acad. Press

## FIFTH SEMESTER

**PAPER: GLY 501C** **L+T+P=4+0+2= 6 credits**
**Palaeontology**
**Palaeontology Practical**

**PAPER: GLY 502C** **L+T+P=4+0+2= 6 credits**
**Hydrogeology**
**Engineering Geology**
**Hydrogeology and Engineering Geology Practicals**

**PAPER: GLY 503 DSE-1** **L+T+P=4+0+2= 6 credits**
**Fuel Geology**
**Fuel Geology Practicals**

**PAPER: GLY 504 DSE-2** **L+T+P=5+1+0= 6 credits**
**Prospecting**
**Mining Geology**

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**PAPER: GLY 501C (Palaeontology)** **L+T+P=4+0+2= 6 credits**
Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

(i) **Course learning outcome**
On completion of the course the students will be able to:

**CO1** Appreciate how fossils get preserved in rocks, the nature of fossil record and how fossils are named in a taxonomic framework

**CO2** Get to know different invertebrate and vertebrates fossil groups, their palaeobiology, and how they can be used in relative dating of rocks.

**CO3** Analyse the indirect evidences preserved in the rocks for the past existence of life.

**CO4** Critically analyse the role of fossils in relative dating of rocks, in interpreting past environments, past distribution of land and sea, and changes in ecosystems over time.

CO5 Understand the changes that occurred in the history of the earth and relate them to their field observations.

**(ii) Broad contents of the course**

Palaeontologists study fossils, the pre-existing organisms which have been preserved in the earth's crust by natural processes and are used to determine the age of the earth in terms of time with the help of relative age of fossils determined by their position in sedimentary rocks with reference to the Geological Time Scale.

Palaeontology includes study of micro-fossils, plant fossils, vertebrate and invertebrate fossils and their evolution. These aspects are fundamental not only to geology and stratigraphy but to inter-disciplinary fields such as paleobotany, paleozoology, evolutionary biology and palaeoecology.

**(iii) Skills to be learned**

The students will acquire skills of discovering and identifying the fossils in the field and describing fossils and their taxonomic classification. They will also learn how to interpret paleoclimate, paleoenvironment conditions and stratigraphic range with reference to the Geological Time Scale.

**(iv)The detail contents of this course**

**THEORY**

**Palaeontology** *Number of Lectures: 60*

Introduction to different branches of palaeontology and its relation to allied sciences (2); Theories of organic evolution interpreted from fossil record (3). Fossils; types of fossils (2). Physico-chemical conditions for fossilization (2); Modes of fossilization (3). Concept of microfossils (2), Ichnology-trace fossils (1) and Palynofossils (2). Taxonomic hierarchy and classification (2).

Descriptive study of invertebrate fossils (Bivalvia, Gastropoda, Cephalopoda, Brachiopoda, Trilobita, Graptoloidea) and their biostratigraphic significance and their paleobiogeographic implications (18). Evolutionary history of invertebrates and vertebrates-Mesozoic reptiles and extinction of dinosaurs; Human evolution (6). A general idea of plant fossils of India with special reference to Gondwana Flora and their Palaeogeographic and palaeoecological significance (4).

Application of fossils in stratigraphy; chronostratigraphy and biostratigraphy- study of rock strata based on their fossil content with the aim of zonation and correlation, use of guide fossils (3). Study of utility of fossils in paleoenvironment, Paleoecology, paleobiogeography, Palaegeophysics, Palaeoneurology, Evolutionary and Economic significance (10).

**PRACTICAL** *Number of Lectures: 30*

Lab will include the study of diagnostic morphological characters, stratigraphic position and age of various invertebrate and vertebrate (20); Study of diagnostic morphological

characters, stratigraphic position and age of Gondwana plant fossils (5); Interpretation and determination of stratigraphic range from the fossil assemblages from Indian stratigraphic horizons (5).

***Recommended Books:***


1. Colbert, E.H. and Minkoff, Eli C. (2001) Evolution of vertebrates, Wiley Liss
2. Cowen, R. (2000) History of Life, Blackwell Science.
3. E. N. K. Clarkson (2013) Invertebrate palaeontology and Evolution, Blackwell Science
4. Michael Benton, (2005) Vertebrate Palaeontology, Blackwell Publishing
5. Michael Benton, David A. T. Harper, (2009) Introduction to Paleobiology and the Fossil Record, Wiley-Blackwell.
6. Morley Davies (2008) An Introduction to Palaeontology, Read Books.
7. Patrick Wyse Jackson, (2019) Introducing Palaeontology: A Guide to Ancient Life, Dunedin Academic Press Ltd.
8. Peter Doyle, Understanding Fossils: An Introduction to Invertebrate Palaeontology.
9. Pratul Kumar Saraswati, M.S. Srinivasan, (2016) Micropaleontology: Principles and Applications, Springer International Publishing Switzerland.
10. Prothero, D.R. (2004); Bringing Fossil to Life An Introduction to Palaeontology (2nd Ed.), McGraw Hill.
11. Raymond Enay (2012) Palaeontology of Invertebrates, Springer-Verlag.
12. Rhona M. Black, (1989) The Elements of Palaeontology, Cambridge University Press
13. Roland Goldring, (2014) Field Palaeontology, Routledge
14. Shrock, R.R. and Towenhofel, W. H.; Principles of Invertebrate Palaeontology, CBS Publishers and Distributors
15. Sreepat Jain (2017) Fundamentals of Invertebrate Palaeontology: Macrofossils, Springer India


**PAPER: GLY 502C (Hydrogeology and Engineering Geology)**

**L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome:**

On completion of the course the students will be able to:

**CO1** Gain knowledge and an understanding of hydrogeological concepts, occurrence and movement of groundwater in the subsurface, exploration, exploitation and recharge of groundwater and

**CO2** Understand the methods of monitoring groundwater quality and sources of pollution,

**CO3** Gain knowledge on rainwater harvesting and artificial recharge of groundwater.

**CO4** Learn about the scope of hydrogeology and its societal relevance.

**CO5** Aware of the importance of geological studies and its applicability to various engineering problems.

**(ii) Broad contents of the course**

This course aims to impart knowledge about the subsurface occurrence and movement of groundwater; monitoring of groundwater level fluctuation; monitoring of groundwater quality and methods of interpreting groundwater quality data. Recharge of groundwater and the methods of groundwater conservation.

To impart sufficient knowledge of engineering geology so as to be able to anticipate the technical problems related to geology of various engineering sites and suggest possible remedial measures.

**(iii) Skills to be learned**

Students will be able to acquire skills of systematic hydrogeological surveys, well inventory, and water quality monitoring. They will learn the skill of preparation and interpretation of water level contour maps and depth to water level maps

The student will be educated on geological site investigations for engineering structures and will provide skills in analysing and interpreting data of engineering properties of soil and rock mass.

**THEORY**

**Hydrogeology** *Number of Lectures: 30*

This course includes hydrologic cycle, precipitation, evapotranspiration, run-off, infiltration and subsurface movement of water (4). Vertical distribution of subsurface water (1). Rock properties affecting groundwater (3). Aquifer, types of aquifers, aquifer properties such as porosity, permeability, Intrinsic permeability and hydraulic conductivity (4). Both qualitative and quantitative study of groundwater (4) Introduction to methods of interpreting groundwater quality data using standard graphical plots (2), the fundamental concepts of groundwater flow including Darcy's law and its validity (3).

It also includes the basic concepts of well hydraulics (2); Groundwater level fluctuations (Well inventory (3). Sea water intrusion in coastal aquifers (2); Rainwater harvesting and artificial recharge of groundwater (2).

**Engineering Geology** *Number of Lectures: 30*

Role of geologists in engineering projects (2), engineering properties of soil and rock (8), Geological consideration with respect to suitability in construction of dams (3), tunnels (5), highways and bridges (6). A study of landslides-their types, causes and mitigation (6).

**PRACTICAL** *Number of Practicals: 20*

**Hydrogeology :**

Field and laboratory methods include determination of mean areal depth of rainfall by Arithmetic Mean (Thiessen Polygon and Isohyetal Method) (5); Preparation and interpretation of water level contour maps and depth to water level maps (5); Graphical representation of chemical quality data and water classification (Trilinear diagrams) (5); and simple numerical problems related to determination of permeability, groundwater flow (5).

**Engineering Geology :** *Number of Practicals:10*

Determination of Liquid limit, Plastic limit, Plasticity index, (4) Coefficient of shear and angle of internal friction from supplied data. (4)

Determination of RQD from supplied data. (2)

***Recommended Books:***

**Hydrogeology :**


1. Brassington, R. (2017) Field Hydrogeology, Wiley Blackwell.

2. Das Subhajyoti (2011) Groundwater Resources of India. National Book Trust. 1st Edition, 248 p.

3. Davis, S.N. and Dewiest R.J.M. (1966) Hydrogeology, John Wiley & Sons.

4. Fetter, C. W., Applied Hydrogeology, Second Edn., CBS Publishers & Distributors, Delhi, India.

5. Karanth, K.R. (1987) Groundwater Assessment Development and Management,Tata McGraw-Hill Education.

6. Hiscock, K. M. (2005) Hydrogeology: Principles and Practice, Blackwell Publishing

7. Hudak, P. F. (1999) Principles of Hydrogeology, Lewis Publishers

8. Raghunath, H.M. (1987) Groundwater,New Age International

9. Todd, D. K. (2006), Ground water Hydrology,2nd Ed., John Wiley & Sons, New York.

10. Todd, D.K. and Mays, L.W. (2004) Groundwater Hydrology, John Wiley & Sons.

**Engineering Geology**

1. A Geology for Engineers - F. G. H. Blyth & M. H. Freitas; ELBS

2. Engineering and General Geology - Parbin Singh; S.K. Kataria & Sons.

3. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.

**PAPER: GLY 503 DSE-1 (Fuel Geology)** **L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome:**

On completion of the course the students will be able to

**CO1** Learn about the basic concepts of Coal Geology with respect to geology as to enable them to work as a Coal Geologist.

**CO2** Understand the generation, migration, entrapment mechanism as well as production of hydrocarbon.

**CO3** Acquire knowledge of the different petroliferous basins of India.

**CO4** Have an idea on conventional and non-conventional fuels and consumption trends through time.

**CO5** Know the types and uses of nuclear fuels.

**(ii) Broad contents of the course**

To provide the student essential and basic concepts of Coal Geology and to study the process, formation, petrography and distribution of coal.

Starting with the history of oil and gas in India, the course comprises the basic concepts of petroleum geology including generation, migration, entrapment, exploration and production of hydrocarbon. Other important topics of this course include oil shale and gas hydrate; and the different petroliferous basins of India and their categories.

**(iii) Skills to be learned**

The students will be appraised about the origin, identification and industrial utilisation of coal.

From this course, student will be able to study wireline logs and do reserve estimation.

**(iv) The detail contents of this course**

**THEORY**

**Coal** No. of class: 15

Definition and origin of Coal (1)
Basic classification of coal (2)
Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal. (6)
Proximate and Ultimate analysis (2)
Coal Bed Methane (CBM): global and Indian scenario (2)
Underground coal gasification (1)
Coal liquefaction (1)

**Petroleum** No. of class: 40

Discovery of Oil and Gas in India; Concept of Crude oil; Petroleum: its different states of natural occurrence; Terminology: Pool, Oil field, Petroliferous Basin, Prospect, Wildcat well, Logging. (6)
Chemical composition of petroleum and natural gas; Characteristics and Properties of source rock, reservoir rock and cap rock; Examples of source rock, reservoir rock and cap rock.
Saturated and Under saturated Reservoir. (6)
Occurrence and Origin of petroleum: Theories of origin of petroleum - Inorganic and Organic theories with supporting evidences; Kerogen: Definition, Types and their significance; Oil Shale;Gas hydrates; Transformation of oil; Oil Window; By products of crude oil. (6)
Migration & accumulation of oil: Primary and Secondary migration; Factors affecting migration and accumulation of oil. (6)
Concept of Entrapment of oil, Classification of Traps: Structural, Stratigraphic, Combination and Hydrodynamic traps. Physical properties of oil. Prerequisite conditions for commercial deposit of petroleum. (6)
Oil-well drilling and drilling fluids parameters; Duties of well-site geologists; Geographical distributions of Onshore and Offshore Petroliferous basins of India and their categories; Oilfields of NE India. (10)

**Other Fuels** No. of class: 5

Gas Hydrate
Nuclear Fuel

**PRACTICAL**

Coal Geology No. of class: 10

Study of hand specimens of coal.
Reserve estimation of coal.

Petroleum Geology No. of class: 20

Study of Wire line logs.
Estimation of oil and Gas reserve.

**Recommended Books:**


1. Textbook of Coal (Indian context) - D. Chandra, R. M. Singh and M. P. Singh, Tara Book Agency, Varanasi.
2. Coal and Organic Petrology - M. P. Singh, Hindustan Publishing Corporation, New Delhi.
3. Textbook of Coal Petrology - E. Stach, Gebruder Bomtraeger, Stuttg
4. The World of Petroleum – B.G. Deshpande, Wiley Eastern Ltd.
5. Petroleum Geology – K.K. Landes, John Wiley and Sons, Inc.
6. Petroleum Geology – F.K. North, Unwin-Hyman.
7. Elements of Petroleum Geology – R.C. Shelly and S.A. Sonnenberg, Academic Press.
8. Petroleum Formation and Occurrence – B.P. Tissot and D.H. Welte, 1984, Springer-Verlag


**PAPER: GLY 504 DSE-2 (Prospecting and Mining Geology)**

**L+T+P=5+1+0= 6 credits**

Total Number of Theory classes (*Lectures*) : 75 (64 hours)
Total Number of Tutorial classes (*Tutorials*) : 15 (15 hours)

**(i) Course learning outcome**

On completion of the course the students will be able to

**CO1** Learn the different types of geological criteria and geological guides for prospecting

**CO2** Learn the different types of pathfinder elements for prospecting various ores

**CO3** Learn the different types of indicator minerals for prospecting various ores

**CO4** Learn the different geophysical procedures for conducting exploration

**CO5** Learn the different mining methods in detail.

**(ii) Broad contents of the course**

The course is centered on the basic principles, methods and applications of mineral prospecting. The geological prospecting methods include recognizing the various geologic criteria and guides for mineral exploration. Geochemical prospecting includes the principles of primary and secondary dispersion of elements, geochemical anomalies and the principles of pedogeochemical surveys, stream sediment surveys, lithogeochemical surveys, hydrogeochemical surveys, biogeochemical surveys and geobotanical surveys. Geophysical prospecting includes geophysical techniques such as

seismic, gravity, magnetic and electrical resistivity methods and their applications in mineral exploration.

The course comprises the mining terminologies and the different methods of surface as well as underground mining. It also includes some important concepts of mining geology such as mine ventilation and mine drainage.

**(iii) Skills to be learned**

The students will acquire skills to identify geologic guides in the field. They will also acquire skills to recognize geochemical and geophysical anomalies

After completion of the course, student will know the different mining terminologies and the mining methods.

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**(iv) The detail contents of this course:**

**THEORY**

**Prospecting :** *Number of Lectures: 30*

Introduction to prospecting;
Geological Prospecting: Principles; Geologic Criteria and Guide; Methods of geological prospecting (10).
Geophysical Prospecting: Principles; Methods and applications of different geophysical prospecting methods (10).
Geochemical Prospecting: Principles and methods; Geochemical field techniques (10).

**Mining Geology :** *Number of Lectures: 45*

An introduction to mining (1);
Mining terminology in opencast and underground mine (5);
Advantages and disadvantages of opencast and underground mining (2).
Methods of mining: Surface mining – Mechanical Extraction methods: Opencast, Open pit, Auger mining, Quarrying, Glory hole (6)
Aqueous extraction methods: Placer mining and Solution mining (6)
Underground mining – Unsupported methods: Gophering, Breast stoping, Underground glory hole (5),
Supported stope methods: Cut and fill, Timbered stoping (6)
Caving methods: Block caving, Sublevel caving (3)
Coal mining methods – Longwall method, Pillar and chamber method (6)
Mine ventilation, Mine drainage (5)

***Recommended Books:***


1. Geophysical Prospecting – M. B. Dobrin; *McGraw Hill Book Company, Inc*.
2. Courses in Mining Geology – R. N. P. Aragoswamy; *Oxford and IBH Publishing Company Pvt. Ltd*.
3. Mining of Ores and Non-metallic Minerals – M. Agoshkov, S. Borisev, and V. Boyarsky; *Mir Publishers*
4. Introductory Mining Engineering - H. L. Hartman; *John Wiley and Sons. Inc*

## SIXTH SEMESTER

**PAPER: GLY 601C** **L+T+P=4+0+2= 6 credits**
**Economic Geology**
**Economic Geology Practical**

**PAPER: GLY 602C** **L+T+P=4+0+2= 6 credits**
**Remote Sensing and GIS**
**Remote Sensing and GIS Practical**

**PAPER: GLY 603 DSE-3** **L+T+P=4+0+2= 6 credits**
**River Science**
**River Science Practical**

**PAPER: GLY 604 DSE-4** **L+T+P=4+0+2= 6 credits**
**Environmental Geology**
**Geological Field Work – II**
**Group Discussion**

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**PAPER: GLY 601C (Economic Geology)** **L+T+P=4+0+2= 6 credits**
Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

**(i) Course learning outcome**
On completion of the course the students will be able to

**CO1** Learn the different processes of ore genesis

**CO2** Learn the different mode of occurrences of the various ore minerals

**CO3** Learn the various uses of ore minerals

**CO4** Learn the different tectonic settings of the formation of ore minerals

**CO5** Learn the geologic and geographic distribution of various ore minerals

**(ii) Broad contents of the course**
The course is designed for the students to understand the concepts of ore genesis, classification of ore deposits, processes of ore mineralization, distribution of ore mineralization in space and time. The course also includes the Indian occurrences of economically important metallic and non-metallic minerals.

**(iii) Skills to be learned**

On completion of the course the students are expected to gain knowledge about various economic minerals, their processes of formation, mode of occurrence and uses.

**(iv) The detail contents of this course**

## THEORY

**Economic Geology** *Number of Lectures: 60*

Scope of Economic Geology; Definition of ore, ore deposit, gangue, tenor, host rock; Resources and reserves- Economic and Academic definitions. Concept of ore genesis; Historical concepts of ore genesis: Man's earliest vocation- Mining, Plutonist and Neptunist concepts of ore genesis (5)

Processes of formation of economic mineral deposits with Indian examples;
Classification of economic mineral deposits (20)

Mode of occurrence of ore bodies; Concept of paragenesis and zoning of ores; Definition of metallogenetic belts, epochs and provinces withexamples; Wall rock alteration; structural, physico-chemical and stratigraphic control of ore localization with examples. Structure and texture of ore deposits Concordant and discordant ore bodies (13)

Ore grade and Reserve, assessment of grade, reserve estimation (2)

Indian Mineral Deposits :
A study of mineralogy, mode of occurrence, origin, uses, and geological distribution of the following metallic/non-metallic mineral/industrial raw material deposits in with reference to their Indian occurrences.
Metallic mineral deposits : Aluminum (Bauxite), Copper, Chromite, Iron, Manganese, Lead & Zinc, Gold, Silver, Platinum, Nickel and Radioactive minerals. (15)

Non-metallic mineral deposits : Limestone, Gypsum, Mica, Sillimanite, Asbestos, Diamond.
Industrial Raw materials : Cement, Glass & Ceramics, Fertilizer, Refractory, Abrasive, Strategic minerals, Gemstones and Building materials (5)

## PRACTICAL *Number of Practicals: 16*

Study of physical properties of the following metallic/non-metallic minerals with reference to their distinguishing physical characters in hand specimen:
Apatite, Asbestos, Barite, Bauxite (Gibbsite), Bornite, Chalcopyrite Calcite, Chromite, Corundum, Dolomite, Fluorite, Galena, Goethite, Graphite, Gypsum, Hematite, Ilmenite, Magnetite, Magnesite, Malachite, Laterite, Limonite, Psilomelane, Pyrolusite, , Pyrite, Siderite, Sphalerite, Stibnite, Sulphur, Talc. (20)

Identification of industrial raw materials in hand specimen for i) Cement ii) Iron and Steel iii) Refractory iv) Glass and Ceramic industry v) Fertilizer.
Identification of constructional materials for roads and buildings. (8)

Ore reserve estimation on bedded deposits. (2)

***Recommended Books:***


1. Mineral Resources of India – D.K. Banerjee, *The World Press Pvt. Ltd., Calcutta*
2. Ores and Minerals: Introducing Economic Geology – J.W Barnes, *Open University Press, Milton Keynes, U.K.*
3. Ore Geology and Industrial Minerals – A.M. Evans, 4th Edn., *Blackwell Scientific Pub., Oxford.*
4. Ore deposits of India – K.V.G.V. Gokhale & T.C. Rao, *Affiliated East-West Press Pvt. Ltd*.
5. The Geology of Ore Deposits – J.M. Guilbert and C.F. Park, Jr., *Freeman*
6. Economic Mineral Deposits – M.L. Jensen and A.M. Bateman, *John Wiley*
7. Understanding mineral deposits – K.C. Misra, *Kluwer Academic Publishers*
8. Ore Deposits – C.F. Park, Jr. & R.A. MacDiarmid, *W. H. Freeman and Company*
9. Economic Geology (Economic Mineral Deposits) – U. Prasad, *CBS Publishers & Distributors*
10. Mineral Economics – R.K. Sinha and N.L. Sharma, *Oxford and IBH Publishing Company Pvt. Ltd*.
11. A Handbook of Economic Geology – A.K. Sen, *Modern Book Agency Pvt. Ltd*.
12. Ore Geology, Economic Minerals and Mineral Economics, Vol, I & II – S.K. Tiwari, *Atlantic Publishers & Distributors (P) Ltd.*


**PAPER: GLY 602C (Remote Sensing and GIS)** **L+T+P=4+0+2= 6 credits**
Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

(i) **Course learning outcome**
On completion of the course the students will be able to:

**CO1** Understand about the fundamentals of remote sensing, photogeology, GIS, and GPS

**CO2** Learn basics remote sensing and GIS techniques

**CO3** Learn use of remote sensing and GIS in different fields.

**CO4** Study the Principles of Remote Sensing and GIS that helps in understanding and building the overall knowledge in a subject which can be applied in Geology.

**(ii) Broad contents of the course**

The course deals with the study of the Principles of Remote Sensing with special stress on Photographic system, digital imaging and Indian Remote Sensing Satellites. The course also gives the Introduction to GIS.

**(iii) Skills to be learned**

The students will be familiarizing themselves with the basic principles of Remote Sensing and GIS. Using the knowledge they will be able to do the visual image interpretation from the geological point of view.

**(iv) The detail contents of this course**

## THEORY

**Remote Sensing and GIS :** *Number of Lectures: 60*

Principles of Remote Sensing - Introduction to Remote Sensing; Remote Sensing processes; Nature of Electro-magnetic Energy – Wave and Particle theory of light, Blackbody radiation principles; Electro Magnetic Spectrum; Interaction of Electro-magnetic Radiation with atmosphere and earth surface features; Atmospheric windows; Energy sources for Remote Sensing; Types of Sensor & Platform; Spectral Response Curves; Types of Remote Sensing; Advantages & limitations of Remote Sensing. (15)

Photographic system – Working Principal and Terminologies of Aerial Photography; Scale and Resolution of the Aerial Photograph; Components of Photographic System – Film, Lens and Filter; Types of Aerial Photography; Acquisition of Aerial Photograph, Drift and Crab; Photographic distortion and displacement; Principles of Stereoscopy; Merits and Demerits of Photographic System. (15)

Concept of Digital Image; Sensor Resolutions; Concept of swath and Nadir; Panchromatic, Multi-spectral and Hyperspectral Images; False Colour Composit.
Orbital Parameters of Remote Sensing Satellites; Geosynchronous and Sun synchronous orbit; LANDSAT and IRS Programme. (10)

Elements of Image Interpretation; Geotechnical Elements; Application of Remote Sensing in Geomorphological, Structural, Lineament and Lithological Mapping; and Environmental Studies. (10)

Introduction to GIS – Elements of GIS; Geospatial database; Spatial data structure; Layer concept in GIS; Functionalities of GIS. (10)

## PRACTICAL

*Number of Practicals: 15*

Stereo Vision test, Use of Pocket Stereoscope, Visual interpretation of satellite image and aerial photograph for interpretation of lineament, lithology, structure, drainage and landuse.

***Recommended Books:***


1. Principles and Applications of Photogeology – S.N.Pandey; *New Age International Publishers*.
2. Remote Sensing Geology – R.P. Gupta; *Springer-Verlag.*
3. Remote Sensing and Image Interpretation – T.M. Lillesand and R.W. Kiefer; *John Wiley and Sons, Inc.*
4. *Remote Sensing and GIS – Basudeb Bhatta; Oxford University Press*
5. *Image Interpretation in Geology – S.A. Drury; Allen and Unwin (Publishers) Ltd.*
6. *Photogeology – V.C. Millere and C.F. Miller; McGraw-Hill Book Company, Inc.*
7. Interpretation of Airphotos and Remotely Sensed Images – R.H. Arnold; *Prentice-Hall, Inc*.
8. An Introduction to Geographical Information Systems – I. Heywood, S. Cornelius and S. Carver; *Longman Group.*


**PAPER: GLY 603 DSE-3 (River Science)** **L+T+P=4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 60 (60 hours)
Total Number of Practical classes (*Practicals*) : 30 (60 hours)

(i) **Course learning outcome**

On completion of the course the students will be able to

**CO1** Understand the river system with reference to sediment and channel flow, sediment source and catchment erosion processes, drainage patterns etc.

**CO2** Have understanding on rivers in time and space, response of rivers to climate, tectonics and human disturbances and river ecology.

**CO3** Learn the basics on fluvial hazards by having knowledge on the integrated approach to stream management.

**CO4** Understand the fluvial degradational and aggradational processes

**CO5** Understand the life cycle of a river especially in relation to societal development.

**(ii) Broad contents of the course:**

Basic stream hydrology, Sediment transport processes in rivers; Drainage, Patterns and Dynamics of alluvial rivers, River response to climate, tectonics and human disturbance, Fluvial hazards; stream management and river ecology.

**(iii) Skills to be learned**

Students will learn the skill how to make stream power calculations, profile analysis and morphometric analysis of streams, to find out stream-length gradient index.

**(iv)The detail contents of this course:**

## THEORY

**River Science :** *Number of Lectures: 60*

Stream hydrology: Basic stream hydrology; Physical properties of water, sediment and channel flow; River discharge; Flood frequency analysis. (10)

River basin: Sediment source and catchment erosion processes; Sediment load and sediment yield; Sediment transport processes in rivers; Erosion and sedimentation processes in channel. (10)

Drainage: Drainage network; Quantitative analysis of network organization-morphometry Random Topology (RT) model and fractal analysis; Role of drainage network in flux transfer Evolution of drainage network in geological time scale. (10)

Rivers in time and space: River diversity in space, Patterns of alluvial rivers - braided, meandering and ana branching channels; Dynamics of alluvial rivers; Channel patterns in stratigraphic sequences.(10)

Channels and Landscapes: Bedrock channels, Bedrock incision process; River response to climate, tectonics and human disturbance; Bedrock channel processes and evolution of fluvial landscapes. (10)

Fluvial hazards: Integrated approach to stream management; Introduction to river ecology. (10)

## PRACTICAL

*Number of Practicals : 15*

Stream power calculation (5), Longitudinal profile analysis; Morphometric analysis; Stream-length gradient index- which is frequently used to highlight the presence of anomalies in areas of intense fluvial erosion (5), Valley-floor to valley-height ratio etc. (5)

***Recommended Books:***


1. Fundamentals of hydrology - Davies, T. (2008); Routledge Publications.

2. Fluvial forms and processes: A new perspective - Knighton, D. (1998); Amold Pubs.

3. Rivers: Forms and processes in alluvial channels - Richards. K. (2004); Balckburn Press.

4. Geomorphology and river management - Bryirely and Fryirs (2005); Blackwell Pub.

5. River Mechanics - Julien, P.Y. (2002); Cambridge University Press.

6. River Processes: An introduction to fluvial dynamics - Robert, A. (2003). Arnold Publications.

7. Rivers over rock - Tinkler, K.J., Wohl, E.E. (eds.) 1998; American Geophyscial Union Monogrpah, Washington, DC


**PAPER: GLY 604 DSE-4 (Environmental Geology; Geological Field Work–II and Group Discussion)** **L+T+P = 4+0+2= 6 credits**

Total Number of Theory classes (*Lectures*) : 48 (48 hours)

**(i) Course learning outcome**

On completion of the course the students will be able to

**CO1** Understand the broad range of geologic events that are damaging to human society

**CO2** Understand the modelling processes of natural hazards

**CO3** Learn the remedial measures that should be undertaken against various natural hazards

**CO4** Undertake geological fieldwork for learning geologic mapping of different lithologies

**CO5** Participate in Group Discussion on various topics of Geology

**(ii) Broad contents of the course**

The contents of the course include earthquakes, tsunamis, landslides, flood and mining on environment, meteoritic impacts; subsidence due to carbonate dissolution and mine-related collapses; hazardous and radioactive waste and problems of their disposal; atmospheric, marine and groundwater pollution; Regional and seasonal disaster profile of India.

**(iii) Skills to be learned**

Students will have knowledge about various natural disasters and their mitigation.

**(iv) The detail contents of this course:**

## THEORY

**Environmental Geology :** *Number of Lectures: 60*

Definition and scope of Environmental Geology. Natural and anthropogenic environmental hazard. (10)
Impacts of earthquake, tsunami, landslide, flood and mining on environment, meteoritic impacts. (20)
Subsidence- Carbonate dissolution and karst topography, Mine-related collapses. (10)
Hazardous and radioactive waste and problems of their disposal. (10)
Atmospheric (Air), marine and groundwater pollution. (5)
Regional and seasonal disaster profile of India. (5)

**Geological Field Work–II :** 1.5 credits

(a) Duration of the Fieldwork is to be of minimum 7 days (*excluding onward and backward journeys*).

(b) An area of about 10 sq. km. is to be geologically mapped; planar and linear structures are to be plotted using standard geological symbols.

(c) Rock specimens are to be collected from the field, identified and labeled.

(d) A detailed Field Report along with the geological map (prepared by the students) is to be submitted before the Sixth Semester Examination and Viva-voce to be conducted.

**Group Discussion :** 0.5 credit

***Recommended Books:***


1. Environmental Geology - Barbara W. Murck, Brian J. Skinner & Stephen C. Porter, *John Wiley and Sons, inc*.
2. Environmental Geology : Indian Context - K. S. Valdiya, *Tata McGraw-Hill Publishing Company Limited*.
3. Understanding Natural Disasters, edited by S. M. Kulshrestha, *published by IGNOU*.

## MATRIX

## MAPPING OF PAPERS TO PROGRAMME SPECIFIC OUTCOMES

**Programme: B.Sc. Geology**

***(use √ if linked)***

| PLOs → | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **PAPERS ↓** | | | | | | | | | | |
| **GLY 101C** | ✓ | | ✓ | | | | | | | |
| **GLY 102C** | ✓ | ✓ | | | | | | | | |
| **GLY 103G** | ✓ | | | | | | | | | |
| **GLY 201C** | ✓ | | | ✓ | | | | | | |
| **GLY 202C** | ✓ | | | ✓ | | | | | | |
| **GLY 203G** | ✓ | | | ✓ | | | | | | |
| **GLY 301C** | ✓ | | ✓ | | | | | | | |
| **GLY 302C** | ✓ | | | ✓ | | | | | | |
| **GLY 303C** | ✓ | | ✓ | ✓ | | | | | | |

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| **GLY 304G** | ✓ | | | | | | | | | |
| **GLY 401C** | ✓ | | | ✓ | ✓ | | | | | |
| **GLY 402C** | ✓ | | ✓ | | ✓ | | | ✓ | ✓ | ✓ |
| **GLY 403C** | ✓ | | ✓ | | ✓ | | | | ✓ | |
| **GLY 404G** | ✓ | | | | | | | | | |
| **GLY 501C** | ✓ | | | ✓ | ✓ | | | | | |
| **GLY 502C** | ✓ | | | | | ✓ | | | | |
| **GLY 503DSE** | ✓ | | | ✓ | | | | | | |
| **GLY 504DSE** | ✓ | | | ✓ | | ✓ | | | | |
| **GLY 601C** | ✓ | | | ✓ | | | | | | |
| **GLY 602C** | ✓ | | | | | | ✓ | | | |
| **GLY 603DSE** | ✓ | | | | | | | | | |
| **GLY 604DSE** | ✓ | | | | | ✓ | | ✓ | ✓ | ✓ |